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The effect of pretreatment with Ascorbic Acid on salt and drought resistance of three varieties of barley

By

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Henckel and Kolotova (1934) developed a simple seed treatment which induced resistance to drought in some plants. Henckel (1938) showed that presowing hardening treatment by alternate soaking and drying method increased the resistance of plants to atmospheric and soil drought. Similar beneficial effects have been observed by Tamhane and Iyengar (1934) in the germination of wheat, Chinoy (1942, 1947) in growth and development of wheat, and Parija and Pillay (1945) in paddy. Parija (1943) working on paddy seeds observed that the pretreated seeds not only recovered from drought earlier but also resisted drought better than the untreated plants Treated plants had higher weight and better grain yield.

Chinoy (1967) developed a method of presowing hardening treatment of seeds by using a low concentration of ascorbic acid.

The laboratory experiments on seed germination have shown that the pretreatment with ascorbic acid stimulated a quicker and higher percentage of germination, more efficient water absorbing capacity, ability to withstand low humid conditions of the atmosphere and more vigorous growth than the untreated seeds in a number of varieties of wheat, barley, oats, sesamum and ragi.

The primary objective of the present investigation was, therefore, to study the effect of presowing hardening treatment of seeds with ascorbic acid on the growth and development of barley, and to understand the role of this pretreatment in the phenomena of drought and salt resistance.

Material and Methods

A modified Tumanov's method of permanent wilting, (Chinoy, 1960) was used in the experiment.

Seeds of three varieties of barley namely N. P. 21 (Indian), Betzes (American) and Spartan (American) were used in the study during the crop season of 1966–67

Presowing hardening treatment was given to all the varieties of seeds by using distilled water as well as a low concentration of ascorbic acid (25 mg/l).

Seeds of these two pretreatments along with control (untreated) were sonw in earthen pots and the layout of the experiment was as follows :

Variety		Pretreatment		Drought treatment		Salt treatment		Replicates		Total
3	×	3	×	3	×	2	×	15	=	810 pots

The three drought treatments were :

(*i*) Normal watering in which the plants received adequate amounts of water to maintain the soil moisture level of 15-20% throughout the growth period ;

(*ii*) Wilting at the tiller initiation stage, in which the watering was stopped as soon as the plants began to tiller ;

(*iii*) Wilting at the shooting stage in which the watering was stopped as soon as the plants began to elongate quickly, which synchronizes with the transformation of the vegetative apex to the reproductive one. The two salt treatments were as follows :

One group of plants consisting of half the total number of pots were allowed to grow in normal soil ; while in the other half a fixed amount of sodium chloride (1500 ppm. per week on dry weight basis of the soil) was added from the 20th day after sowing until maturity.

Both these non-salt and salt series of plants were subjected to wilting at tillering and shooting stages along with the fully watered plants.

Witling was given for a period of eight days and three soil moisture determinations were recorded on second, fifth and eighth day of this period. After the termination of the period of wilting, the effect was determined by noting the precentage number of plants surviving and making full recovery which is termed as "Survival value".

Height of the main stem, as well as leaf and tiller numbers were determined for ten plants at random from two weeks after sowing and continued till harvest. Two plants were uprooted every week from each treatment and fresh and dry weights of root, leaf and stem were recorded.

Soil salinity was studied by electrical conductivity determinations in terms of millimhos/cm and ppm.

Experimental findings

Of the three varieties used in this expeiment, N. P. 21 was an early variety, Betzes a medium one while the Spartan belonged to the late flowering class. The application of the sodium chloride at the concentration of 1500 ppm. did not bring about any change in the growth characters of the plant in the beginning. At the end of the first month after sowing, all the plants came to tillering stage when the assigned pots were subjected to wilting. At this time the plants of the saline series received three additions of sodium chloride. This helped to maintain a higher soil moisture in these series with the result that the plants showed the symptoms of wilting from fifth day only while the plants of normal soil entered the wilting stage from the third day. The observation that, the lower concentrations of salinity can be used as a beneficial factor in the growth of barley, confirms earlier finding in this laboratory (unpublished data).

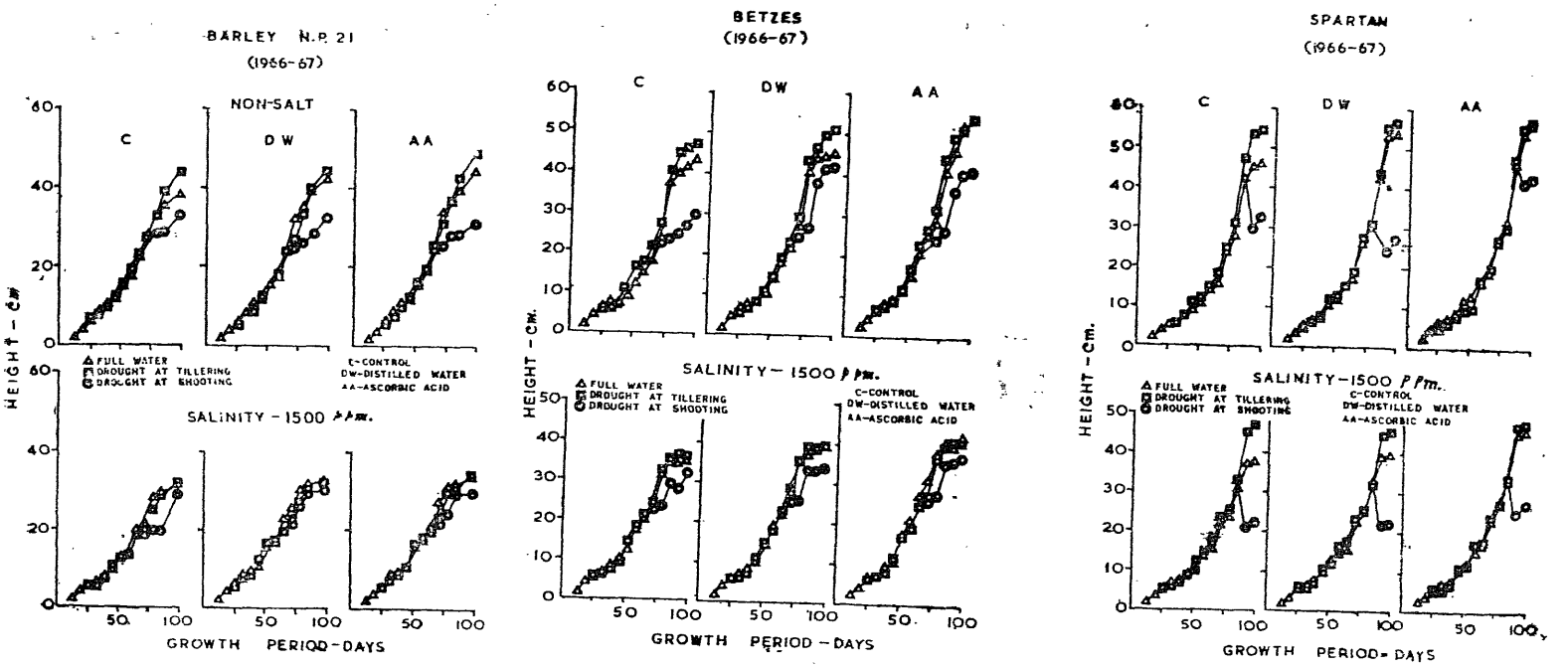

Fig. 1. Effect of water stress, salinity and pre-sowing treatment of seed with DW and AA on stem elongation of three varieties of barley.

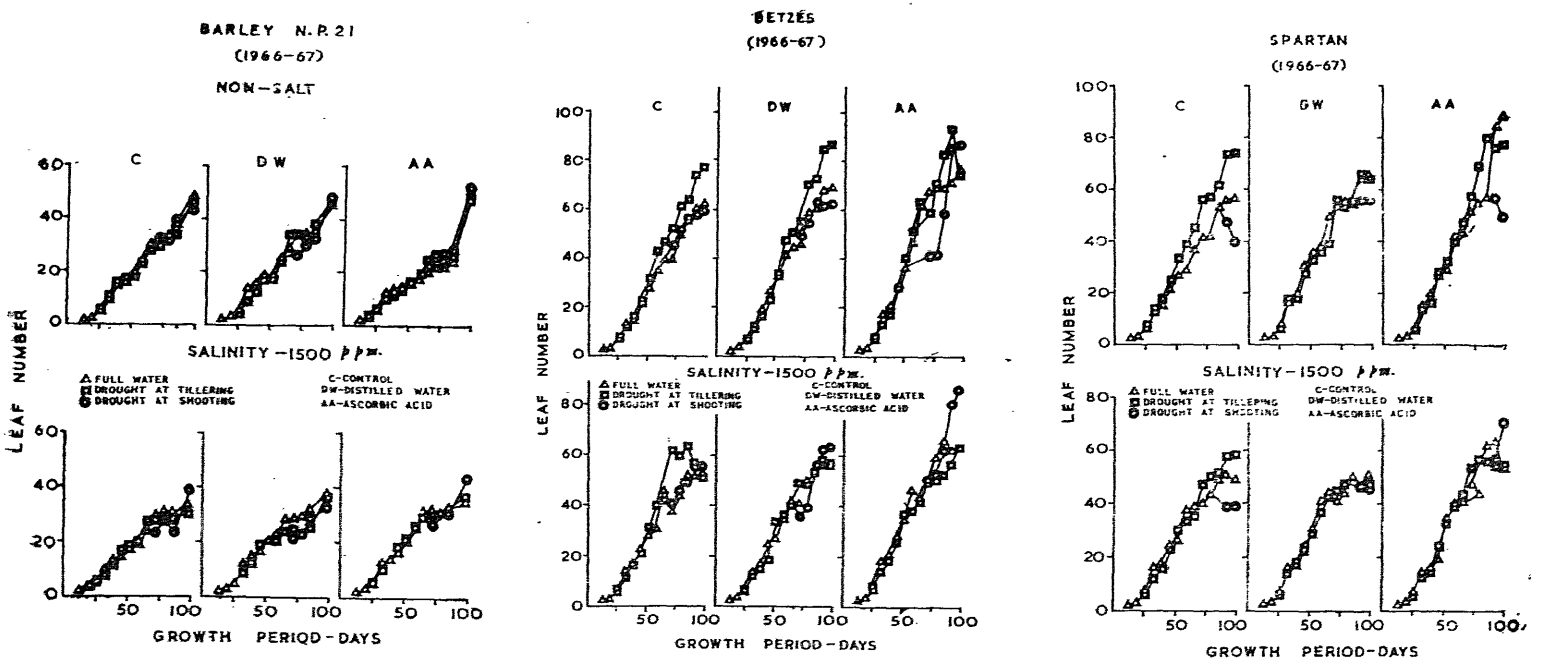

Fig. 2. Effect of water, stress, salinity and pre-sowing treatment of seed with DW and AA on leaf production of three varieties of barley.

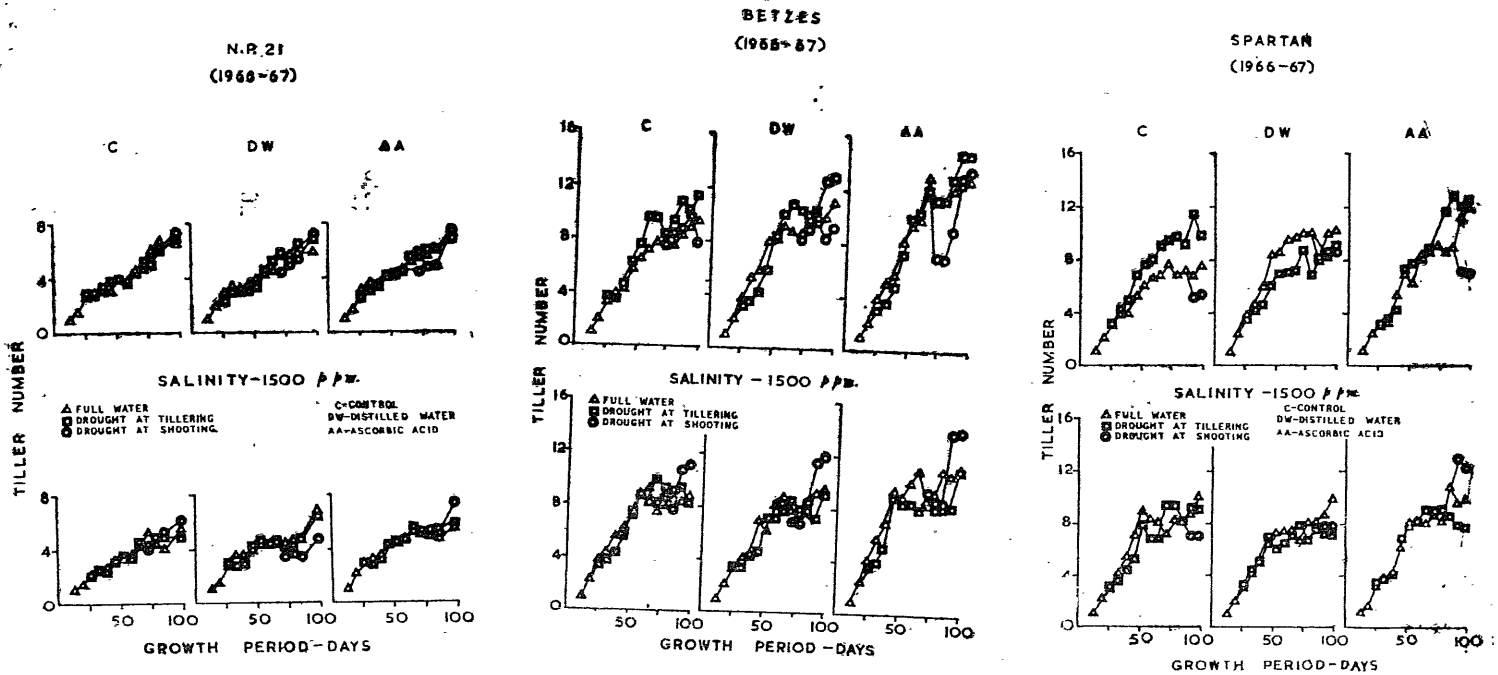

Fig. 3. Effect of water stress, salinity and pre-treatment of seeds with DW and AA on tiller production of three varieties of barley.

The data of growth characters taken at weekly intervals is presented for height of the main shoot, leaf and tiller number in Figs. 1, 2 and 3.

Analysis of height, leaf number and tiller number lead to the following observations. In the beginning there was no apparent decrease in the height due to the presence of salt. This trend continued for about 8 weeks till the seventh addition of salt was done. After that the plants began to show symptoms of growth reduction with a low percentage of mortality. During this period the soil had received an adequate amount of sodium chloride amounting to more than 10,000 ppm. which was sufficient to retard growth. Further it was observed that later additions of sodium chloride substantially affected the growth characters especially the height.

TABLE 1

Drought intensity and survival value (Non-salt Series)

Variety and treatment	Wilting at tillering				Wilting at shooting			
	%soil moisture	Mean temp.	Drought intensity	%survival value	%soil moisture	Mean temp.	Drought intensity	%survival value
N. P. 21								
Control	13·3	21·3	12·9	95·5	8·9	23·6	21·1	17·0
DW	12·0	21·3	14·2	97·3	8·4	23·6	22·5	11·6
AA	13·1	21·3	13·0	98·5	10·3	23·6	18·4	20·4
Betzes								
Control	11·7	21·3	14·6	96·5	8·8	23·6	21·4	14·2
DW	14·4	21·3	11·9	92·8	9·0	23·6	20·9	14·2
AA	12·4	21·3	13·8	96·3	8·1	23·6	23·3	29·6
Spartan								
Control	14·0	21·3	12·2	93·8	11·1	26·0	18·8	28·7
DW	13·3	21·3	12·9	95·8	11·7	26·0	17·7	30·8
AA	13·3	21·3	12·3	98·1	8·2	26·0	25·3	44·0
			Salt Series					
N. P. 21								
Control	14·4	21·3	11·8	100·0	13·3	23·6	14·2	52·6
DW	13·5	21·3	12·7	100·0	12·6	23·6	14·9	51·2
AA	13·0	21·3	13·1	100·0	11·2	23·6	16·9	63·6
Betzes								
Control	13·0	21·3	13·1	100·0	14·3	23·6	13·2	32·3
DW	11·1	21·3	15·3	100·0	13·8	23·6	13·7	52·0
AA	11·0	21·3	15·5	100·0	13·7	23·6	13·7	61·3
Spartan								
Control	14·4	21·3	11·9	100·0	16·5	26·0	12·6	23·0
DW	12·7	21·3	13·4	100·0	15·6	26·0	13·3	29·2
AA	13·1	21·3	13·0	100·0	13·9	26·0	14·9	52·9

This retardation in growth affected all the three varieties studied, irrespective of the earliness or lateness of a variety.

Effect of Wilting

As mentioned earlier, the plants of salt and non-salt series were subjected to wilting at tiller initiation and shooting stages. Wilting at tiller initiation stage did not affect their subsequent growth. The survival value was found to be inversely proportional to the drought intensity. In the saline series of plants there was 100% survival from wilting at tillering stage. Wilting at this stage did not damage the plants but on the other hand proved beneficial to growth and developmental characters.

Those plants which were subjected to wilting at shooting stage were affected adversely as seen from a higher percentage of mortality and reduced growth. A few plants which were able to survive wilting, came to flowering with poor seed setting.

The plants of saline series were also affected adversely during the period of wilting at shooting stage. Though the percentage of mortality was less in saline series, there was a considerable reduction in height, leaf number and tiller number.

The salt concentration at this stage reached a maximum value of 25 millimhos/cm. at 25°C (16,000 ppm.).

Effect of Pretreatment

The effect of presowing hardening treatment of seeds was found to be beneficial not only for germination but also for growth and development. An increase in height, leaf number and tiller number was observed in the pretreated plants.

Another point worthy of mention here is the percent survival value of the wilted plants (Table I). Plants from pretreated seeds were better able to resist the adverse conditions of wilting compared to those from untreated seeds.

Discussion

The fact that the deficiency of water retards growth and reduces the yield has been reported by a number of workers like (Slatyer, 1957, 1963), Levitt (1963), Russell (1961), Chinoy (1952, 1955, 1960), John (1965) and Chinoy *et al.* (1965). However, the most important consideration in this matter is the alteration in the expression of vegetative and reproductive characters which are directly influenced by the immediate environment of the plant growth.

It is well known that the presence of salt depresses the growth and yield of the plant. But an increased percentage of survival value observed in the saline conditions during wilting at tillering stage, when compared to the non-saline conditions, was due to the fact that the former was able to maintain a higher level of moisture even during the period of wilting. This water retaining capacity has been consistently observed in previous experiments also.

The wilting at tiller initiation stage has shown a slight depression in height as well as tiller number immediately after recovery, but it was soon changed by a later enhancement in growth. This wilting treatment has triggered the physiological actions which ultimately resulted into an increased growth. Wilting at shooting stage on the other hand, directly affected the physiological processes taking place at the apex which was in the process of transformation from the vegetative to the reproductive stage. This period also synchronized with the stage of maximum tiller production which was also affected by wilting. During the survival period a number of plants produced a new set of tillers which may be due to the suppression of the main shoot.

The presence of sodium chloride showed a similar trend to the wilting treatments. But in general the plants showed a greater depression in all the growth characters. After wilting at shooting stage many of the tillers were unable to survive and were not able to produce a new set of tillers as observed in non-salt-series of plants.

Seedlings raised from seeds pretreated with distilled water and ascorbic acid when subjected to wilting gave a better result as can be observed from table. This also holds good for the saline series too. During both the wilting periods (tillering and shooting) the plants of pretreated seeds gave a better survival value especially those pretreated with ascorbic acid.

There was a greater increment in the height of the ascorbic acid pretreated plants compared to those in the control plants.

Under wilting treatments AA pretreatment stimulated the plants to resist the adverse conditions of drought better than the control plants where a low percentage of survival was observed in all the varieties studied.

A comparatively better growth and greater percentage of survival in the pretreated plants of saline series when compared to the control plants of the same series also explains the usefulness of this presowing treatment which acts as a protection to the salt injury.

Summary

The effect of presowing hardening treatment of seeds have been studied in three varieties of barley belonging to early, medium and late flowering classes, namely N. P. 21, Betzes and Spartan respectively. The former is an Indian variety while the latter two are American varieties.

A complex factorial experiment was carried out in the present study. Pretreated seeds of ascorbic acid (25 mg/l) and distilled water along with control (untreated) were used in the experiment. Wilting was given to two groups of plants at their tillering and shooting stages. Salt resistance was studied by the application of sodium chloride.

The following results are obtained :

1. An acceleration in the emergence of seedlings was observed in pretreated seeds.
2. Application of NaCl depressed growth. The reduction in growth was greater in the case of plants raised from seeds which had not received any pretreatment.
3. The increment in dry matter production was greater in the plants of two pretreatments than the control.
4. Drought at tillering stage had an enhancing effect on growth and brought about earliness in flowering.
5. The wilting at shooting stage resulted in reduced growth of the plants in almost all treatments.
6. The presence of NaCl in the soil helped to maintain a higher moisture level during the wilting period of tillering stage, which in turn maintained a higher percentage of survival.
7. The beneficial effect of pretreatments in growth as well as developmental characters, especially with AA has been observed consistently in all the varieties studied.

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A comparative account of the dimensions of bony elements of the feeding apparatus of certain Herons (Family : Ardeidae)

By

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Herons, which belong to the family Ardeidae normally live in the vicinity of aquatic habitats and are known to feed on a number of aminals which include insects, arachnids, crustaceans, fishes, amphibians, reptiles and even small mammals. However, the primary food of all the herons is not necessarily the same. For instance, the Little egret (Egretta garzetta gerzetta Linn.) which prefers to live towards the edge of the lakes, primarily feeds on fishes of about three to four centimeters in length. Aquatic insects are also accepted by these birds to supplement their diet of fishes. The Pond heron (Ardeola grayi SYKES) on the other hand prefers to live in the vicinity of shallow ponds, puddles and other similar habitats and feedson a mixed diet consisting of insects, fishes, tadpoles and small reptiles and shows no preference for any diet as such. The Cattle egret (Bubulcus ibis coromandus BODDAERT) prefers to associate with the grazing cattles and feeds primarily upon insects generally disturbed by the cattles in the near vicinity of fields. It also makes a meal out of blood sucking flies, ticks and other parasitic insects from backs and bellies of the cattles. Occasionaly it feeds on fishes. Thus though herons feed primarily upon animal diet inculuding fishes and insects however their feeding preferences are quite different. It is quite logical to expect that these differences in the feeding behaviour manifest themselves in structural variations in their feeding apparatuses.

A study of the dimensions of the bony elements of the feeding apparatus of birds has been done in the past to assess the structural adaptations in those birds. Fisher (1944) was among the first to work in this direction while investigating the feeding apparatus of Cathertid vultures. Goodman and Fisher (1962) have also studied the dimensions of the skulls of a number of birds belonging to the family Anatidae. Very recently Rawal (1966) and Malhotra (1967) worked on some picarion group of birds and passerines respectively and have found out that a definit correlation exists between the feeding behaviour and its apparatus. The present work has been extended to find out whether such correlation exists among the different members of the family Ardeidae also. The birds whose skulls have been studied here include Little egret, Pond heron and Cattle egret.

Methods of Study

The skulls were prepared by removing the muscles from the skulls and keeping them in 5% KOH and 10% glycerine. The alizarine staining technique, modified by James (1961) was used to prepare stained skulls. The statistical study of various bony elements was done by methods adopted by Goodman and Fisher (1962).

Observations

The following is a tabulated statement of the dimensions of the bony elements meas ur ed in millimeters.

TABLE 1

Dimensions of body length and the bony elements of skulls of Little egret, Pond heron and Cattte egret in Millimeters

Name of element	No. of specimen	Observed range	Mean	Standard deviation	Coeff. variation
(1*a*) Little egret					
Body length	6	295·0–325·0	309·50±4·53	10·13	3·2%
Skull length	6	122·1–132·7	126·00±1·91	4·29	3·4%
Cranial length	6	40·9– 42·3	41·48±0·29	0·65	1·5%
Bill length	6	80·7– 88·2	83·56±1·20	2·70	3·2%
Premaxillary length (Ant. to nares)	6	62·8– 68·9	64·90±1·11	2·50	3·8%
Palatine length	6	30·5– 32·0	31·41±0·21	0·49	1·5%
Mandible length	6	113·5–122·8	117·58±1·67	3·75	3·1%
Quadrate length	6	7·0– 8·0	7·50±0·13	0·31	4·1%
(1*b*) Pond heron					
Body length	6	230·0–255·0	242·50±4·09	9·16	3·7%
Skull length	6	90·1–105·5	97·91±4·11	9·20	9·3%
Cranial length	6	37·1– 40·8	38·40±0·63	1·42	3·7%
Bill length	6	58·5– 63·2	60·23±0·85	1·92	3·2%
Premaxillary length (Ant. to nares)	6	41·7– 47·2	43·90±0·86	1·94	4·4%
Palatine length	6	25·5– 27·5	26·50±0·31	0·70	2·7%
Mandible length	6	85·8– 96·7	90·73±1·79	4·00	4·4%
Quadrate length	6	7·0– 8·0	7·41±0·16	0·37	5·1%
(1*c*) Cattle egret					
Body length	6	260·0–285·0	272·00±4·62	10·34	3·8%
Skull length	6	99·0–105·0	102·00±1·03	2·31	2·3%
Cranial length	6	42·0– 49·0	44·00±1·22	2·75	6·2%
Bill length	6	59·0– 68·0	63·33±1·99	4·47	7·5%
Premaxillary length (Ant. to nares)	6	43·0– 54·0	48·16±2·06	3·96	8·2%
Palatine length	6	29·0– 31·0	30·25±0·33	0·75	2·4%
Mandible length	6	89·0–101·0	95·66±2·22	4·97	5·1%
Quadrate length	6	10·5– 12·5	11·33±0·30	0·63	6·0%

Based on the above mentioned observations the mean percentage ratios of the various body elements of the skulls were calculated. These ratios are as follows :

TABLE 2

Mean percentage ratios of the various bony elements of the skulls (Fig. 4)

Ratios	Little egret	Pond heron	Cattle egret
Skull length to Body length	70·000±·023	89·10±0·002	72·20±0·08
Skull length to Cranial length	303·00±0·18	250·30±0·062	226·00±0·06
Bill length to Cranial length	200·00±0·022	156·00±0·011	141·00±0·03
Premaxilla (Ant. to nares) to Cranial length	155·00±0·01	113·00±0·014	107·00±0·03
Palatine length to Cranial length	76·10±0·002	69·00±0·009	68·00±0·01
Mandibular length to Cranial length	283·00±0·03	235·00±0·031	217·00±0·04

It may be stated that the readings as recorded above are based on a study of at least six skulls of each species. (Figs. 1, 2, 3).

Discussion

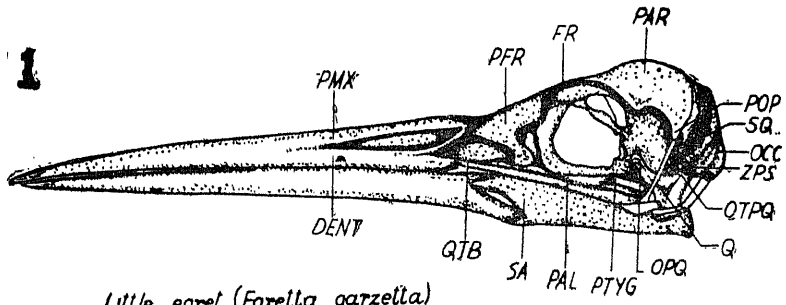
It is generally known that birds which feed on fish and similar aquatic animals have longer beaks. The ibis, stork, pelican, king-fisher, water fowls and herons are some familiar examples. A longer beak enables fish-eaters to seize the fish and hold it with great ease. Generally a fish eating bird plunges in water and then make use of the bill as forceps. Some birds forage by moving their bills through shallow water. Rynchops, is perhaps one of the most specialised bird which uses its long beak for foraging by taking back and forth its lower jaw cutting the water.

So far the only account of the dimensions of the fish eaters that is available is from the investigations conducted by Goodman and Fisher (1962) as a part of studies in the functional anatomy of the feeding apparatus in the water fowls (Fam : Anatidae). The have recorded actual measurements of the different elements of the skulls of a number of water birds with different feeding habits. The birds studied by them included among others the Common mergansers which are known to feed mainly on fishes. Their observations showed that, though a long beak is a general characteristic of the water fowls, a variance in ratios existed mainly depending upon the feeding behaviour. On the bases of the ratios pertaining to skull length, bill length and mandibular length, they observed that the fish eating waterfowls stood apart with a relatively long skull, bill, and mandible. The bill length of Common merganser which mainly depends upon fish varied from 57·7 to 70·3 mms and the mean percentage ratio of the bill length to cranial length was 126·0%. The corresponding figures for the waterfowl Hyemalis which feeds on waterweeds showed that the bill length ranged from 29·6 to 32·5 mms, the mean percentage ratio being 64%.

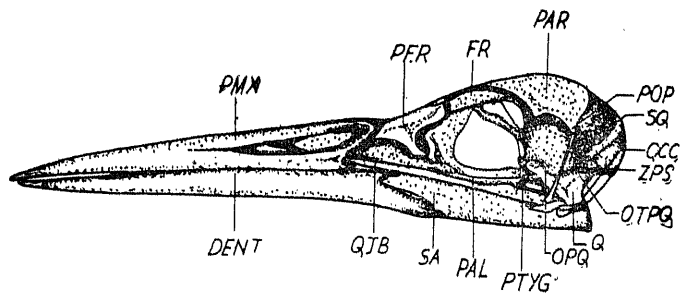
The primary food of a heron family consists of fish and as an adaptation to this feeding habit they posses long beak. All the three herons studied here are also known to feed on fish at one time or the other. Of these the Little egret is often seen solitary on streams, lakes marshes, ponds etc. and as studied by Dharmkumarsinhji (1955), prefers the small shallow streams where it does most of its fishing. Its chief food is fish and a careful study of its feeding behaviour shows that it waits patiently for the fish often running up and down. When the fish is

ABBREVIATIONS

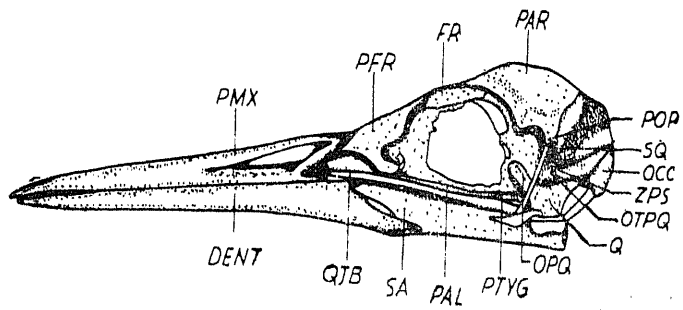
ART.—Articular ; BSTP.—Basitemporal : CON.—Condyle ; DENT.—Dentary ; FOR.—Foramen magnum ; FR.—Frontal ; MX.PL.PR.—Maxillopalatine processes ; NR.—Nerial opening ; NS.—Nasal ; OCC.—Occipital ; OPQ.—Orbital process of quadrate ; OTPQ.—Optic process of quadrate ; Q.—Quadrate ; PAL.—Palatine ; PAR.—Parietal ; PMX.—Premaxilla ; POP.—Postorbital process ; PSPH.—Parasphenoid ; PTYG.—Pterygoid ; SA.—Surangular ; SQ.—Squamosal ; VOM.—Vomer ; ZPS.—Zygomatic process.



Little egret (Egretta garzetta)

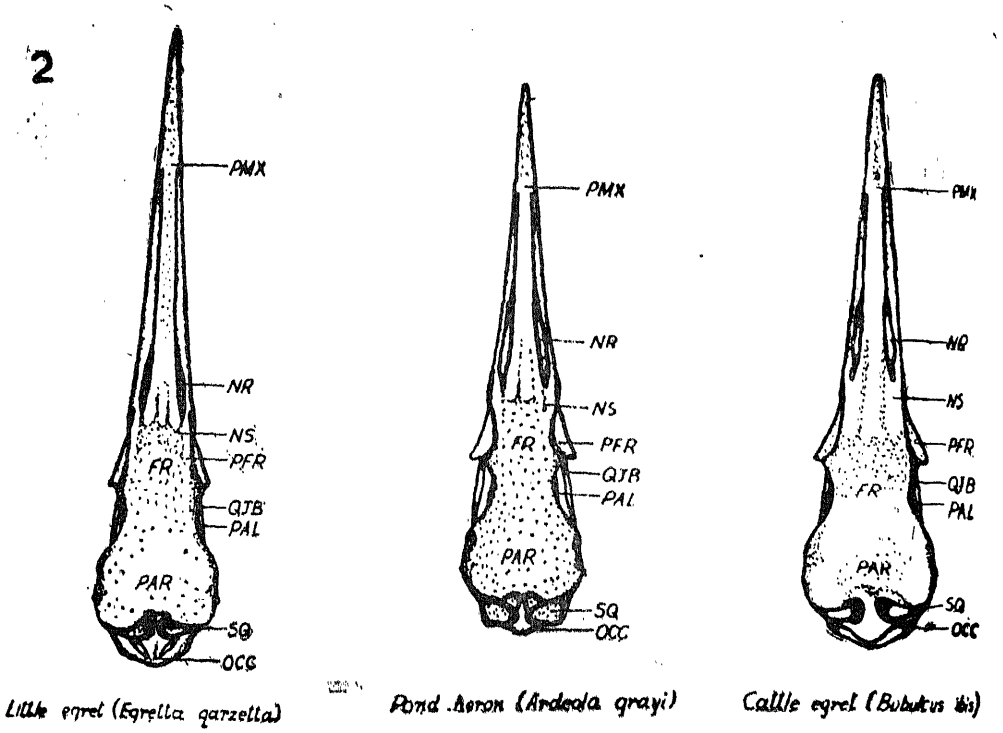


Pond heron (Ardeola grayi)

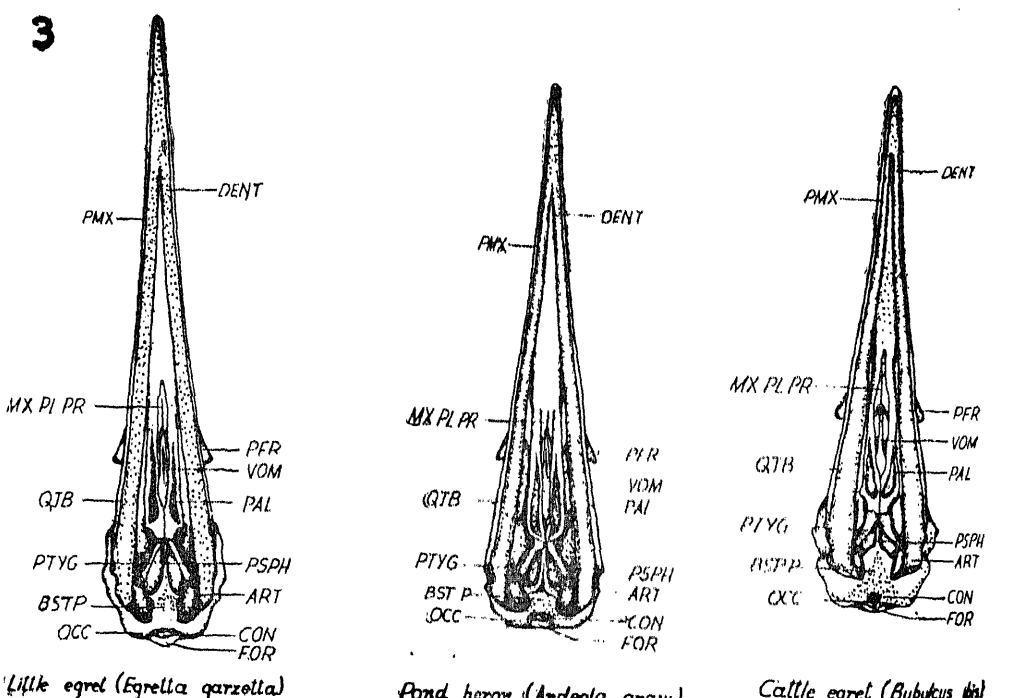


Cattle egret (Bubulcus ibis)

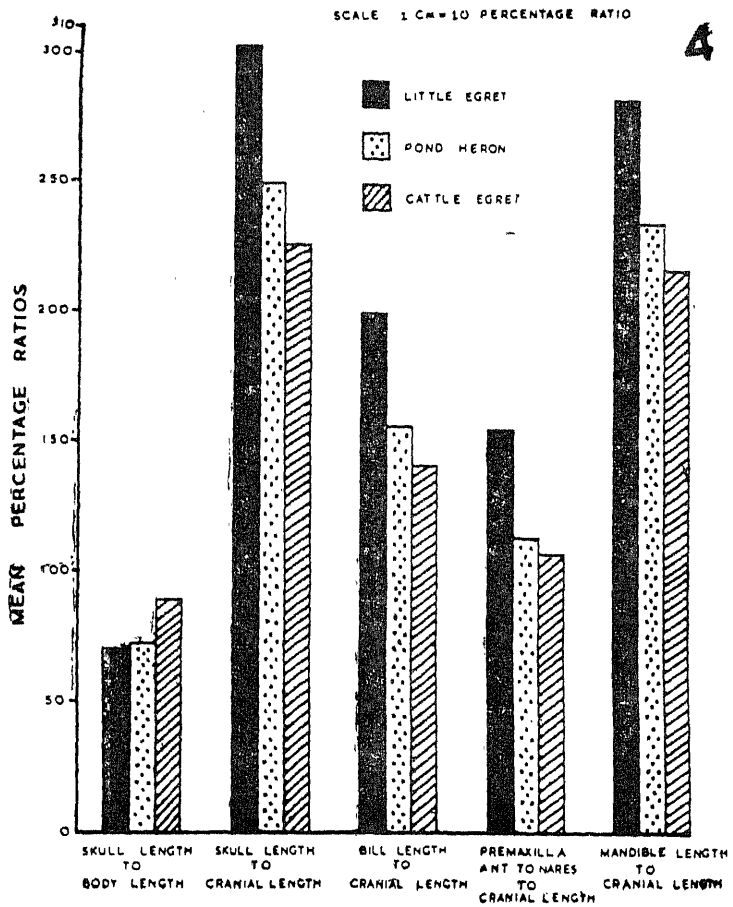
1, Lateral view of skulls.



2. Dorsal view of skulls.



3. Ventral view of skulls.



4. Histogram showing comparative mean percentage ratios of the various bony elements of the skulls of the Little egret, Pond heron and Cattle egret.

first caught it is generally held transversely, but with a quick jerk it turns the fish by about 90° and gulps it as whole. The Pond heron no doubt also feed on fishes but it is not active piscine freder and the fish is not necessarilly its main food. The fishes eaten are generally smaller and other available animals such as frogs and insects are equally valued by this heron. It visits human habitations and feeds on animals growing in the shallow and dirty puddles. The Cattle egret on the other hand is known to move away from aquatic stituations. Rather than w. it for a fish, it prefers to move along with the herds of cattles and eats insects disturbed by them. The ticks and mites from the bellies of cattles are also liked and eaten by them. Thus as is noted, the Little egret feeds chiefly on fish, the Pond heron feeds on any aquatic animal it comes across including fishes whereas the Cattle egret feeds on insects, ticks and mites and takes rarely to fishes.

A study of the body length of the herons shows that the Pond heron is the shortest and Little egret the longest among the birds studied (Table 1). The skull

length and bill length is also known to vary in view of the body length. The longest cranium is that of the Cattle egret. But the observations of the mean precentage ratios of the skull and bill length to the cranium show that both the skull as a whole as well as the bill are longest in the Little egret (Table 1). The figures of the ratios of the bill length of the Little egret is 200·00 as against 156·00 in Pond heron and 141·00 in Cattle egret (Table 2). These values confirm the contention that the fish eaters have generally longer beaks and that the longest beak among the herons studied is that of the Little egret which lives chiefly on fishes (Figs. 1, 2, 3). Of the remaining two, the Cattle egret depends much less upon the fish than the Pond heron. This has been manifested by the fact that though the bill ratio of Pond heron is smaller than that of the Little egret, it is higher than that of the Cattle egret.

Summary and Conclusions

1. A study of the body length and the dimensions of the osteological elements of the feeding apparatus of Little egret (Egretta garzetta garzetta), Pond heron (Ardeola grayie) and Cattle egret (Bubulcus ibis) has been undertaken.

2. The average dimensions of the body length of these herons are 309·50 mms for the Little egret, 242·50 mms for Pond heron and 272·00 mms for Cattle egret. The skull length of these birds is 126·00 mms, 97·91 mms and 102·00 mms respectively.

3. The mean percentage ratios of the skull length to cranial length (303·00), bill length to cranial length (200·00) and mandibular length to cranial length (283·00) are highest in Little egret which feeds mainly on fishes. These ratios are lowest in Cattle egret (226·00, 141·00 and 217·00) which hardly depends upon fish for its food. While the corresponding ratios are of intermediate in Pond heron (250·00, 156·00 and 235·00) which feeds all aquatic organisms including fishes.

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The effect of various nitrogen sources on the growth and sporulation of *Cephalothecium roseum* Corda causing pink rot of apple (*Malus sylvestris* (Mill.)

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Introduction

Nitrogen is one of the indispensable elements for the growth of fungi. It has structural as well as functional importance and occurs in fungi in the form of complex organic nitrogenous compounds. The growth and sporulation of fungi vary considerably when these are supplied with different nitrogenous compounds (Wolf and Wolf, 1947 ; Hawker, 1950 ; Lilly and Barnett, 1951 ; Cochrane, 1958 ; Tandon, 1961). The present paper deals with the influence of various nitrogen sources on the growth and sporulation of *Cephalothecium roseum* Corda. Such a study has not been carried out previously on this organism.

Materials and Methods

The materials and methods were the same as already described by the authors in their earlier paper (Thind and Madan, 1967)

The basal medium consisted of Dextrose 20 gm, KH_2PO_4 10 gm, $MgSO_4$ $7H_2O$ 0·250 gm, $Fe_2(SO_4)_3 6H_2O$ 0·005 gm, and distilled water 1000 ml. Each nitrogen compound* was used in amount calculated to give 693 mg of nitrogen per litre, which is present in 5 gm of KNO_3 per litre of the basal medium.

The degree of sporulation was measured on the basis of average number of spores present per low power field of the compound microscope and recorded in the following grades :

Number of spores per low power field of the microscope	Degree of sporulation	Symbol used
No spore	Nil	–
1 – 10	Poor	+
10 – 20	Fair	++
20 – 30	Good	+++
Above 30	Excellent	++++

*Peptone, yeast extract and casein hydrolysate were added at the rate of 5 gm each per litre of the basal medium.

The growth of the fungus on different media has been termed excellent, good, fair and poor on the basis of its following dry mycelial weights :

Category	Dry weight, mg
Excellent	Above 200
Good	100 – 200
Fair	50 – 100
Poor	Below 50

Experimental Work

Thirty six nitrogen compounds comprising of 9 inorganic compounds, 5 amides and 22 amino acids were tested separately as the sole source of nitrogen for the growth and sporulation of *C. roseum*. The data on dry weight, sporulation and final pH are summarised in Table 1, 2 and 3.

TABLE 1

Effect of various inorganic and some organic compounds used singly as sole source of nitrogen on growth and sporulation of *C. roseum* after 20 days of incubation at 28°C. Initial pH adjusted to 6·0.

Nitrogen source	Dry wt. in mg	Sporulation	Final pH
Control (without nitrogen)	0	–	6·0
Potassium nitrate	208	++++	6·6
Potassium nitrite	0	–	6·0
Sodium nitrate	200	++++	6·6
Sodium nitrite	0	–	6·0
Ammonium oxalate	232	++++	6·5
Ammonium sulphate	112	+++	3·6
Ammonium nitrate	135	+++	3·6
Ammonium chloride	108	+++	3·3
Ammonium phosphate	126	+++	3·6
Urea	178	++++	6·4
Asparagine	207	++++	6·8
Peptone	205	++++	6·4
Yeast extract	225	++++	6·1
Casein hydrolysate	180	++++	6·5

Experimental Results

The data summarised in Table 1 indicate that *C. roseum* showed excellent growth with ammonium oxalate, yeast extract, potassium nitrate, asparagine, peptone and sodium nitrate and good growth with casein hydrolysate, urea, ammonium nitrate, ammonium phosphate, ammonium sulphate and ammonium chloride. It showed excellent or good sporulation with most of the inorganic and organic compounds tested. However, there was neither any growth nor any sporulation with nitrites of potassium and sodium.

It is clear from Table 2 that *C. roseum* showed excellent growth with β-alanine, DL-aspartic acid, DL-serine, L-glutamic acid, DL-threonine, L-tyrosine, DL-valine, L-asparlic acid, DL-tryptophane, glycine, L-arginine HCl, DL-norvaline and DL-α-alanine ; good growth with DL-leucine, L-cystine and DL-phenylalanine ; fair growth with DL-histidine mono HCl, L-isoleucine and DL-histidine dihydrochloride and poor growth with DL-methionine, L-lysine mono HCl and DL-lysine mono HCl. It showed excellent or good sporulation in general, with all the amino acids tested here.

TABLE 2

Effect of various amino acids used singly as sole source of nitrogen on the growth and sporulation of *C. roseum* after 20 days of incubation at 28°C. Initial pH adjusted to 6·0 :

Nitrogen source	Dry wt. in mg	Sporulation	Final pH
Control (without nitrogen)	0	–	6·0
Glycine	220	++++	6·3
L-isoleucine	80	++	5·5
DL-leucine	175	++++	5·7
DL-α-alanine	202	++++	6·2
β-alanine	255	++++	6·0
DL-Valine	225	++++	5·5
DL-norvaline	212	++++	6·4
DL-threonine	240	++++	6·2
DL-serine	245	++++	6·3
L-cystine HCl	150	++++	5·8
DL-methionine	40	+	4·2
L-arginine HCl	215	++++	5·1
L-lysine mono HCl	35	–	6·1
DL-lysine mono HCl	25	–	6·0
L-aspartic acid	225	++++	7·7
DL-aspartic acid	250	++++	8·0
L-glutamic acid	240	++++	7·5
DL-phenylalanine	114	+++	5·8
L-tyrosine	238	++++	5·7
DL-tryptophane	222	++++	5·8
DL-histidine mono HCl	95	++	5·7
DL-histidine dihydrochloride	56	–	5·7

H-ion-concentration is known to influence markedly the utilization of KNO_2 by different fungi. Therefore, an experiment was set up to find out the effect of whole range of pH on the growth and sporulation of *C. roseum* on KNO_2. It is clear from Table 3 that *C. roseum* showed no growth at pH 2–6, while it showed good growth at pH 7–10 and no growth at pH 11. It showed excellent sporulation at pH 7–9 and good sporulation at pH 10.

TABLE 3

Effect of different hydrogen-ion-concentration on the utilization of potassium nitrite on the growth and sporulation of *C. roseum* after 20 days of incubation at 28°C.

Initial pH	Dry wt. in mg	Sporulation	Final pH
2	0	–	2·0
3	0	–	3·0
4	0	–	5·6
5	0	–	5·6
6	0	–	6·2
7	150	++++	7·3
8	166	++++	7·8
9	187	++++	8·2
10	138	+++	8·3
11	0	–	9·0

Discussion

Potassium nitrate and sodium nitrate showed excellent growth of *C. roseum* studied here. A large number of fungi worked out by many workers have been reported to utilize nitrates well. However, some fungi such as *Penicillium digitatum* (Fergus, 1952), *Schizophyllum commune* (Swack and Miles, 1960), *Thraustochytrium* spp. (Goldstein 1963) and others either cannot utilize nitrates or utilize them poorly.

Potassium nitrite and sodium nitrite both did not support any growth of the present fungus on the acidic medium. Nitrites are generally toxic on the acidic pH range because in this range these exist in the form of undissociated nitrous acid which exerts the toxic effect because of its destructive influences on the proteins and amino acids of the fungal cells (Cochrane and Conn, 1950; Lilly and Barnett, 1951; Foster, 1949; Cochrane, 1950 and 1958). Likewise, *C. roseum* could not make any growth at pH 2–6 but made good growth at pH 7–10 on potassium nitrite as the sole source of nitrogen. Similar results have also been reported by other workers like Tandon and Agarwal (1953) with *Fusarim coeruleum*, Thind and Duggal (1957) with *Colletotrichum glocosporioides*, Thind and Rawla (1959) with three anthracnose fungi, Sethi and Munjal (1963) with *Cercospora viticola*, Thind and Mandahar (1965) with *Cercospora hibiscina*, *C. withaniae* and *C. crotalariae* and Mandahar (1965) with *Pleospora indica*.

C. roseum made excellent growth with ammonium oxalate. Good growth with ammonium oxalate is reported for *Curvularia lunata* (Agnihotri, 1958) and *Sclerotium oryzae* (Sethunathan, 1964). Rest of the ammonium salts yielded good growth of *C. roseum* and this is reported to be true of several other fungi, in general. However, there are some fungi such as *Coprinus lagopus*, *Pleurotus corticatus* (Leonian and Lilly, 1938), *Blastocladiella emersonii* (Barner and Cantino, 1952), *Sapromyces elongatus* (Golueke, 1957) and *Phytophthora fragariae* (Davies, 1959) which have been reported to be unable to utilize ammonium nitrogen.

Urea supported good growth of *C. roseum*. Same is true of *Gloeosporium papayae*, *G. musarum* and *Colletotrichum papayae* (Tandon and Grewal, 1956), *Alternaria ricini* (Pawar and Patel, 1957*a*), *Phythum* spp. (Saksena 1940), *Colletotrichum capsici* (Thind and Randhawa, 1957), *Cercospora hibiscina* (Thind and Mandahar, 1965), *Morchella esculenta* (Brock, 1951) and *Rhizopus oryzae* (Lockwood *et al.*, 1936). However, Srivastava (1951) and Mandahar (1965) have observed poor growth of *Curvularia lunata* and *Pleospora indica*, respectively, on urea.

Asparagine supported excellent growth of the present fungus. Similarly, it is effeciently utilized by *Pestalotia psidii* (Patel, *et al.*, 1950), *Colletotrichum* sp. (Thind and Rawal, 1959), *Cercospora hibiscina* (Thind and Mandahar, 1965) and *Pleospora indica* (Mandahar, 1965). However, Schade (1940) and Wolf and Schoup (1943) reported that asparagine was not utilized by *Leptomitus lacteus* and *Allomyces* sp., respectively.

Peptone, yeast extract and casein hydrolysate all supported excellent or good growth of the present fungus. These are reported to be good sources of nitrogen for the growth of fungi, in general.

β-alanine, DL-aspartic acid, DL-serine, DL-threonine, L-glutamic acid, L tyrosine, DL-valine, L-aspartic acid, DL-tryptophane, glycine, DL-arginine HCl, DL-norvaline, DL-α-alanine, DL-leucine, L-cystine and DL-phenylalanine all supported excellent or good growth of *C. roseum* studied here. Many other fungi have also been reported to make good growth on these amino acids. However, fungi growing poorly on these sources are also known. Thus β-alanine supported poor growth of *Tilletia caries* (Zscheile, 1951) and *Helminthosporium sativum* (Peterson and Katznelson, 1954) ; DL-aspartic acid of *Gloeosporium papayae*, *G. musarum* and *Colletotrichum papayae* (Tandon and Grewal, 1956) ; DL-serine of *Chalara quercina* (Beckman *et al.*, 1953) ; DL-threonine of *Colletotrichum capsici* (Thind and Randhawa, 1957) ; L-glutamic acid of *Alternaria ricini* and *Phomopsis vaxans* (Pawar and Patel, 1957*a* and *b*); DL-tryptophane of *Colletotrichum* sp. (Thind and Rawla, 1959) ; Glycine of *Gloeosporim psidii* (Thind and Rawla, 1959) ; *Leptomitus lacteus* (Schade, 1940) and *Phyllosticta artocarpina* (Tandon and Bilgrami, 1957) ; L-arginine of some *Hymenomycetes* (Yusef, 1953) ; DL-norvaline of *Cercospora withaniae* (Thind and Mandahar, 1965) and *Gloeosporium psidii* (Thind and Rawla, 1959); L-cystine of *Cercospora hibiscina* (Thind and Mandahar, 1965) and *Gloeosporium psidii*, *G. piperatum* and *Colletotrichum* sp. (Thind and Rawla, 1959) ; and DL-phenylalanine of *Venturia inaequalis* (Pelletier and Keitt, 1954).

DL-histidine mono HCl, L-iso-leucine, DL-histidine dihydrochloride, DL-methionine, L-lysine mono HCl and DL-lycine mono HCl all supported fair or poor growth of *C. roseum*. Similarly, DL-leucine supported poor growth of *Gloeosporium psidii* (Thind and Rawla, 1959); DL-methionine of *Cercospora withaniae* (Thind and Mandahar, 1965) ; DL-lysine of *Colletotrichum* sp. (Thind and Rawla, 1959). However, DL-histidine supported good growth for *Cercospora hibiscina*, *C. withaniae* and *C. crotalariae* (Thind and Mandahar 1965).

In general, compounds which supported best mycelial growth also yielded excellent sporulation ; conversely, compounds supporting poor growth yielded poor sporulation. Potassium nitrate and sodium nitrate both supported excellent sporulation of *C. roseum*. Similarly, good sporulation for *Alternaria tenuis* B strain (Grewal, 1955), few isolates of *Pestalotia psidii* (Patel *et al.*, 1950), *Melanconium fuligineum* (Timnick *et al.*, 1951) has been observed on these two nitrates. However, sodium nitrate showed poor sporulation of *Colletotrichum lindemuthianum* (Mathur *et al.*, 1950).

All the ammonium salts tested here showed excellent or good sporulation of the present fungus. Ammonium salts, in general, are considered to be poor sources for sporulation for a large number of fungi studied so far by various workers. Fair or poor sporulation has been reported for *Colletotrichum capsici* (Thind and Randhawa, 1957), *Ustilago zeae* (Wolf, 1953), and *Phyllosticta cycadina* (Tandon and Bilgrami, 1954) and *Alternaria tenuis* B strain (Grewal, 1955).

Urea, asparagine, peptone, yeast extract and casein hydrolysate all supported excellent sporulation of *C. roseum*. All these nitrogen sources, in general, are

reported to support good sporulation of a large number of fungi. However, casein hydrolysate supported poor sporulation of *Colletotrichum capsici* (Thind and Randhawa, 1957).

β-alanine, DL-aspartic acid, DL-serine, DL-threonine, L-glutamic acid, L-tyrosine, DL-valine, L-aspartic acid, DL-tryptophane, glycine, L-arginine HCl, DL-norvaline, DL-α-alanine, DL-leucine, L-cystine and DL-Phenylalanine all supported excellent or good sporulation for *C. roseum* studied here. Similarly, excellent or good sporulation with DL-α-alanine, DL-valine, DL-leucine, glutamic acid and L-arginine HCl has been reported for *Colletotrichum capsici* (Thind and Randhawa, 1957). Good sporulation on glycine has been reported of *Monilinia fructicola, Phoma betae, Neocosmopara vasinfecta and Septoria nodorum* (Lilly and Barnett, 1951). However, poor or no sporulation on glycine has been reported for *Colletotrichum capsici* (Thind and Randhawa, 1957), *Alternaria tenuis* B strain (Grewal, 1955) and *Colletotrichum lindemuthianum* (Mathur *et al.*, 1950).

L-iso-leucine, DL-methionine and DL-histidine mono HCl showed fair or poor sporulation of *C. roseum*, while L-lysine mono HCl, DL-lysine mono HCl and DL-histidine dihydrochloride failed to sporulate on these sources. Similarly, L-histidine mono HCl supported poor sporulation but DL-iso-leucine yielded good sporulation of *Colletotrichum capsici* (Thind and Randhawa, 1957).

Summary

Growth and sporulation of *C. roseum* were studied on different nitrogen sources used singly. Excellent growth was observed with β-alanine, DL-aspartic acid, DL-serine, DL-threonine, L-glutamic acid, L tyrosine, ammonium oxalate, yeast extract, DL-valine, L-aspartic acid, DL-tryptophane, glycine, L-arginine HCl, DL-norvaline, potassium nitrate, asparagine, peptone, DL-α-alanine and sodium nitrate; good growth with casein hydrolysate, urea, DL-leucine, L-cystine, ammonium nitrate, ammonium phosphate, DL-phenylalanine, ammonium sulphate and ammonium chloride ; fair growth with DL-histidine mono HCl, L-iso-leucine and DL-histidine dihydrochloride ; and poor growth with DL-methionine, L-lysine mono HCl and DL-lysine mono HCl ; and no growth with nitrite of potassium and sodium. In general, compounds which supported best mycelial growth of *C. roseum* yielded its excellent sporulation ; conversely, compounds supporting poor growth yielded poor sporulation.

C. roseum was observed to utilize potassium nitrite only on the alkaline range 7–10 of the medium but not on the acidic pH range 2–6.

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Ecology of *Cyperus rotundus* L. VI. Effect of Clipping on Tuber Production and Growth

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Introduction

Cyperus rotundus L. is a very troublesome weed of cultivation. In order to control the spread of this weed, farmers employ various means. During the process of weed removal, aerial shoots are no doubt removed but the underground perennating parts (tubers) lie undamaged and sprout in due course of time giving rise to aerial shoots. The tubers of *C. rotundus* after 21 days of planting, have been reported to produce new tubers (Smith and Fick, 1937 ; Hauser, 1962). The production of tubers thus seems to be dependent on the availability of sufficient food materials which are manufactured by the above ground parts. It was, therefore, proposed to study the effect of removal of tops on tuber production and subsequent growth of the plants of *C. rotundus*.

Experimental Procedure

Earthenware pots of uniform size were filled in with soil passed through 2 mm sieve to ensure the absence of tubers in it. *C. rotundus* tubers of almost equal size collected from a local wheat field were sown in the pots on 2nd February, 1966. Each pot contained 4 tubers which sprouted after about a week. When the aerial shoots were established which happened after about one month of sowing, they were subjected to the clipping schedule indicated in table 1.

TABLE 1

Clipping schedule of the aerial shoots of Cyperus retundus L.

Treatments	Clipping interval in days	Date of 1st clipping	No. of clipping	Date of last clipping
Control	No clipping	–	0	–
1	20	2nd March, 1966	3	11th April, 1966
2	15	,,	4	16th ,, ,,
3	10	,,	5	11th ,, ,,
4	5	,,	10	16th ,, ,,
5	3	,,	16	16th ,, ,,

For each treatment 4 replicates were maintained. For final observation and recording of data, the plants under treatments 3, 1 and control were washed on 11th May, 1966 while those under rest 3 treatments were washed on 16th May, 1966. Thus, in all the clipping treatments one month period was given for recovery after the last clipping. Data regarding number of aerial shoots per pot,

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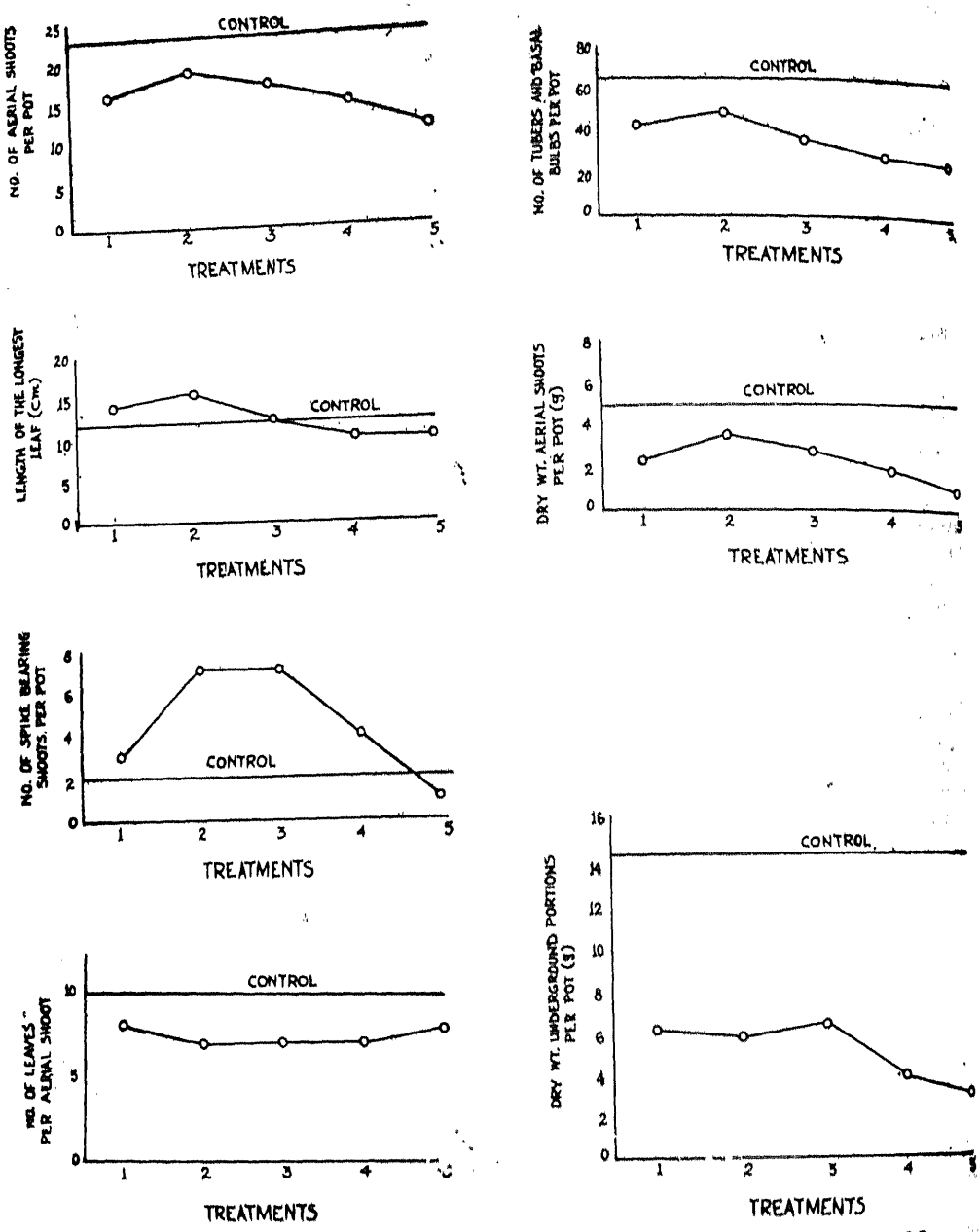

Fig. 1. Effect of different clipping treatments on growth and tuber production of *Cyperus rotundus* L.

Control—unclipped plants

Treament 1, Plants clipped at 20 days interval.
" 2, Plants clipped at 15 days interval.
" 3, Plants clipped at 10 days interval.
" 4, Plants clipped at 5 days interval.
" 5, Plants clipped at 3 days interval.

number of leaves per aerial shoot, average length of the longest leaf, number of tubers and basal bulbs per pot, number of spike bearing aerial shoots per pot, dry weight of aerial shoots and underground portions per pot were collected in case of each treatment. The data were statistically analysed for the test of significance (table 2).

Results

Data collected in each case, are summarised in table 2.

TABLE 2

Effect of different clipping treatments on growth of Cyperus rotundus L.

Growth	Treatments						Differences significant at	Critical differences
	Control	1	2	3	4	5		
No. of aerial shoots/ pot	23	16	19	17	15	12	5% level	5·5
No. of leaves/ aerial shoot	10	8	7	7	7	8	5% level	1·9
Length of longest leaf (cm)	12·2	14	15·6	12·1	10·4	10·1	1% level	2·7
No. of tubers and basal bulbs/pot	64	42	49	36	28	25	1% level	18
No. of spike bearing shoots/pot	2	3	7	7	4	1	–	–
Dry wt. aerial shoots/pot (g)	5·05	2·42	3·7	2·93	1·9	1·05	1% level	1·54
Dry wt. underground portions/ pot (g)	14·2	6·22	5·8	6·35	3·82	2·8	1% level	3·01

A perusal of table 2 reveals that significant differences within the treatments exist in case of all the listed characters except the number of spike bearing shoots per pot. The values of characters like number of aerial shoots per pot, number of leaves per aerial shoot, number of tubers and basal bulbs per pot, and dry weight of aerial shoots and underground portions per pot are decreased on clipping. Reduction in tuber production and in dry weight of aerial shoots and underground portions, is very much marked. These characters show significant differences within the treatments even at 1% level of significance (table 2).

An interesting finding of this experiment is marked reduction in number of tubers and basal bulbs per pot which is 64 in case of unclipped set at the time of harvest and is reduced to 25 when the aerial shoots are clipped at 3 days interval for a period of 2 months. Tuber production, in general, goes on decreasing with increase in clipping frequency (Fig. 1).

Discussion

Clipping treatment has been shown to adversely affect the growth of a number of plant species (Nelivigi, 1962 ; Sant, 1965). In case of *C. rotundus* also, clipping, in general, significantly reduces the growth of the plants which show lower values for a number of growth characters recorded, *viz.*, number of aerial shoots per pot, number of leaves per aerial shoot, number of tubers and basal bulbs per pot and dry weight of aerial and underground portions per pot. With

increase in frequency of clipping, plant growth goes on decreasing. Plants clipped at 20 days interval, however, show less values for number of aerial shoots per pot, length of the longest leaf, number of tubers per pot, number of spike bearing shoots per pot and dry weight of aerial shoots per pot as compared with the plants clipped at 15 days interval (*see* table 2 and Fig. 1) but the differences within these two treatments are insignificant. The value for the length of the longest leaf obtained in case of plants clipped at 15 days interval is significantly higher than that in unclipped set. This behaviour of the plant, however, could not be explained.

Out of characters showing decrease in their values on clipping, the population of tubers which are the main perennating organs in case of *C. rotundus*, is quite important and hence requires detailed treatment. Marked reduction in tuber population (from 64 per pot in unclipped set to 25 in the set clipped at 3 days interval) is perhaps due to insufficient food products available for storage. It may be mentioned that the decrease in tuber population bears direct correlation with frequency of clipping, *i.e.*, higher the frequency of clipping more the decrease (fig. 1). This suggests that the reduction in tuber population is largely governed by the rate of removal of photosynthate. The practical implication of this finding, if economical, may be very useful in reducing the reproductive capacity of this weed whereby the ecological success of the weed may also be reduced sufficiently.

Conclusions

Clipping has got depressive effect on growth of *C. rotundus* as evidenced by the reduction in number of aerial shoots per pot, number of leaves per aerial shoot, number of tubers and basal bulbs per pot, and dry weight of shoot and underground portions per pot ; thus, higher the frequency of clipping, more severe the reduction in growth.

In unclipped set the tuber population per pot is 64 while it is 25 in case of plants clipped at 3 days interval for a period of 2 months. Thus, the removal of aboveground parts of *C. rotundus* has considerably great reducing effect on its tuber production.

Acknowledgements

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Population Structure in *Tulipa stellata* Hook. I. Phenotypic Variability

By

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An essential feature of all outbreeding groups of individuals is the diversity of form. The total variability in such a population depends upon : (*i*) reshuffling of the genetic material through recombination, and (*ii*) the occurrence of mutations. Though the variation pattern and population structure of most of the western plant species has already been worked out, little has been done in this direction with regard to the oriental species. Recently, however, Venkateswarlu and Chiganti (1966) have studied *Coix aquatica* from this angle.

Tulipa stellata Hook., a bulbous annual (of family, Liliaceae) exhibits considerable diversity in form in the Kashmir valley. The species is extended over various habitats between altitudes of 1524–2438 meters (Hooker, 1894). Stray plants have been collected from the Panjab plains (altitude 304·8 meters). The present work is directed towards understanding population dynamics of this taxon. Natural populations of Pampore, Shankracharya and Manasbal have been considered for extensive studies. The habitats are ecologically different. Pampore is a silty plateau, Shankracharya an eroded mountain now under afforestation and Manasbal a lake area. In all, sixteen characters have been analysed. The data has been tabulated below.

TABLE 1

Quantitative Characters

Character	Pampore population			Shankracharya population			Manasbal population		
	No. of plants	Mean	S.E.	No. of plants	Mean	S.E.	No. of plants	Mean	S.E.
Plant height	114	28·8 ± 5·0 cm		83	30·3 ± 1·1 cm		196	23·5 ± ·3 cm	
Leaf number per plant.	127	4·4 ± ·03 cm		175	4·1 ± ·03 cm		300	4·1 ± ·02cm	
Length of the lowest leaf.	127	18·4 ± ·15 cm		175	15·9 ± ·4 cm		300	13·6 ± ·18cm	
Flower size	134	4·6 ± ·11 cm		190	4·07 ± ·02 cm		125	3·3 ± ·07cm	
Anther size	134	1·2 ± ·03 cm		–	–	–	125	1·1 ± ·03cm	

TABLE II

Qualitative Characters

Character	Pampore population		Shankaracharya population		Manasbal population	
	Number	% age	Number	% age	Number	% age
Nature of the lowest 3 leaves :						
(*a*) Curled	225	59·05%	214	40·6%	224	24·8%
(*b*) Straight	156	40·9 %	312	59·3%	676	75·1%
Colour of leaf margin :						
(*a*) Red	333	86·04%	264	63·3%	700	79·3%
(*b*) Green	54	13·8 %	153	36·6%	182	20·6%
Scape :						
(*a*) Unbranched	114	99·1 %	255	100%	296	100 %
(*b*) Branched	1	·9 %	Nil	–	Nil	–
Pedicel colour :						
(*a*) Red	106	78·5 %	200	84·7%	280	90 9%
(*b*) Green	29	21·4 %	36	15·2%	28	9·09%
Number of perianth lobes :						
(*a*) Six	134	100%	195	97·5%	285	97·6%
(*b*) Five, seven, eight	Nil	–	5	2·5%	7	2·3%
Margin of perianth lobes :						
(*a*) Entire	131	97·7 %	376	98·9 %	844	95·04%
(*b*) Notched	3	2·2 %	4	1·5%	44	5 %
Shape of inner perianth lobes :						
(*a*) Obtuse tip	373	94·6 %	224	46·6%	196	54·4%
(*b*) Acute tip	21	5·3 %	256	52·5%	164	45·5%
Shape of outer perianth lobes :						
(*a*) Obtuse tip	351	88·6 %	426	74·7%	310	8 ·6%
(*b*) Acute tip	45	11·3 %	144	25·2%	65	17·3%
Colour of outer perianth lobes (from within) :						
(*a*) Pink	15	3·7 %	249	15·7%	Nil	–
(*b*) Yellow	138	34·3 %	Nil	Nil	Nil	–
(*c*) White	249	61·7 %	1333	84·2%	1014	100%
Colour of outer perianth lobes (from outside) :						
(*a*) Pink	402	100%	1611	100%	1014	100%
Colour of inner perianth lobes (from within) :						
(*a*) Pink	15	3·7 %	249	15·6%	Nil	–
(*b*) Yellow	138	34·3 %	Nil	–	Nil	–
(*c*) White	249	61·7 %	1338	84·3%	1014	100%

Character	Pampore population		Shankaracharya population		Manasbal population	
	Number	% age	Number	% age	Number	% age
Colour of inner perianth lobes (from outside) :						
(*a*) Pink	15	3·7 %	249	15·6 %	Nil	–
(*b*) Yellow	138	34·3 %	Nil	Nil	Nil	–
(*c*) White	249	61·7 %	1338	84·3 %	1014	100 %
Nectary :						
(*a*) Flowers with nectary	135	95·7 %	161	96·9 %	245	98 %
(*b*) Flowers without nectary	6	4·2 %	5	3·01%	5	2 %
Nectary colour :						
(*a*) Light violet	492	55·4 %	570	59·06 %	564	37·6 %
(*b*) Violet	63	7·09 %	104	10·7 %	96	6·5 %
(*c*) Deep yellow	240	27·02 %	160	16·5 %	600	40·8 %
(*d*) Light yellow	27	3·04 %	46	4·7 %	90	6·1 %
(*e*) Chocolate	51	5·7 %	86	8·9 %	120	8·1 %
(*f*) Purple	15	1·6 %	Nil	–	Nil	–
Filament colour :						
(*a*) Light violet	84	9·3 %	59	11·3 %	78	8·5 %
(*b*) Violet	486	54·3 %	292	56·3 %	314	34·8 %
(*c*) Light yellow	24	2·6 %	19	3·6 %	52	5·7 %
(*d*) Deep yellow	228	25·5 %	100	19·3 %	376	41·2 %
(*e*) Chocolate	48	5·3 %	36	6·9 %	68	7·4 %
(*f*) Purple	12	1·3 %	Nil	–	6	·6 %
(*g*) White	12	1·3 %	12	2·3 %	18	1·9 %
Anther colour :						
(*a*) Yellow	174	24·1 %	170	16·5 %	520	26·8 %
(*b*) Violet	408	56·6 %	692	67·4 %	1136	58·6 %
(*c*) Purple	78	10·8 %	84	8·1 %	150	7·7 %
(*d*) Pink	60	8·3 %	80	7·7 %	132	6·7 %

Discussion and Conclusions

The nature of diversity observed in the three populations of *Tulipa stellata* is complex but as Heslop-Harrison (1955) rightly points out, the mere inspection of phenotypes is not sufficient to categorise the variations of a population. This is particularly true for the habitual outbreeding species where distinctive character combinations are sorted out generation after generation from the flux of forms occurring in wild populations.

The data presented includes sixteen characters, of which eleven are qualitative and the remaining quantitative. The latter are plastic as they are easily influenced by the environment. Qualitative characters, on the contrary, are conservative as they are less susceptible to environmental influences. As such, some if not all, the variations observed in the populations of *T. stellata* are genetic. This is further supported by the fact that the variants were collected from one

habitat and the same population. This will be finally confirmed by experimental cultivation of phenotypic variants under similar environmental conditions.

Our studies on the cytological structure of these populations (to be described elsewhere) indicate the presence of three chromosomol races : diploid (2n=24) and two types of tetraploids (2n=4X=48). Occurrence of polyploidy is apt to cause a section of the population to exhibit distinct quantitative differences from others. There are evidences that the cytological variants constitute a connected series originating from the diploid base and floating in the population. These chromosome races do not only perpetuate through vegetative propagation accomplished by the production of droppers (Kachroo, 1951) but contribute substantially to the quantum of variability through outbreeding.

Summary

Phenotypic variability has been analysed in three populations of *Tulipa stellata*. Of the sixteen characters studied, five are quantitative and the remaining qualitative. Variability, particularly with regard to qualitative characters is regarded as genetic because the variants occupy similar habitat. This inference is also supported by the fact that polyploidy is frequent in this species. Presence of polyploids is regarded to cause at least a section of the population to exhibit differences.

Acknowledgements

Our grateful thanks are due to Prof. P. Kachroo and Prof. R. Misra for critically going through the manuscript and making some changes.

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Female reproductive organs of *Coquillettomyia indica* (Cecidomyiidae : Diptera)

By

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The present paper gives an account of the female reproductive organs of the gall midge *Coquillettomyia indica*, sp. nov. The midges were collected by author from the Company Garden, Allahabad, where they were found in abundance, sitting on the cobwebs on the twigs of large banyan tree. The midges are dirty orange coloured, small and delicate : in the collection, very few males were obtained.

Description of the organs

Ovipositor :

The ovipositor is lamellate type and falls under, 'oviducte a lamelles' of Kieffer's (1900)[2] classification of gall midge ovipositor. It is incapable of perforating the plant tissue. In captivity the females were found releasing the eggs on the wall of the glass chimney in which they were collected. Some of the females were seen under the binocular microscope, passing eggs one by one, when they were held for dissection (fig. 8).

The ovipositor is formed by the modification of eighth and ninth abdominal segments (figs. 1, 2, 6). Segments one to seven are normal abdominals, having separate tergites and sternites. The intersegmental membrane between seventh and eighth is slightly extended. The eighth segment is long, tubular and thin, there being no separate tergum and sternum. Its anterior end is nearly as wide as the posterior end of the seventh segment while the other end is narrow and continuous with the ninth segment. The ninth segment is also thin but not membranous. It is nearly half the eighth segment in length and distally carries a pair of dorsal and a median ventral lamella, (figs. 3-5). Ventrally the ninth segment is highly sclerotized at its free edges and is fringed with minute dense setae. The dorsal lamellae are leaf-like, broad and curved structures attached dorsolaterally at the posterior border of the ninth segment. The lamellae are beset with minute dense setae and prominent long spines (figs. 2, 4). The ventral lamella, situated ventrally in between the dorsal lamellae, is a small triangular (finger-like in side view, fig. 3) structure beset with minute setae. It is wide at base but bluntly pointed at tip ; dorsal and ventral lamellae measure 0·664 × 0·032 and 0·024 × ·008 mm respectively.

The terminal three abdominal segments are so arranged that at rest nearly half of the ninth segment gets concealed inside the eighth and the eighth together with the ninth is accommodated in the seventh. The lamellae, however, remain exposed to the outside (figs. 3, 6).

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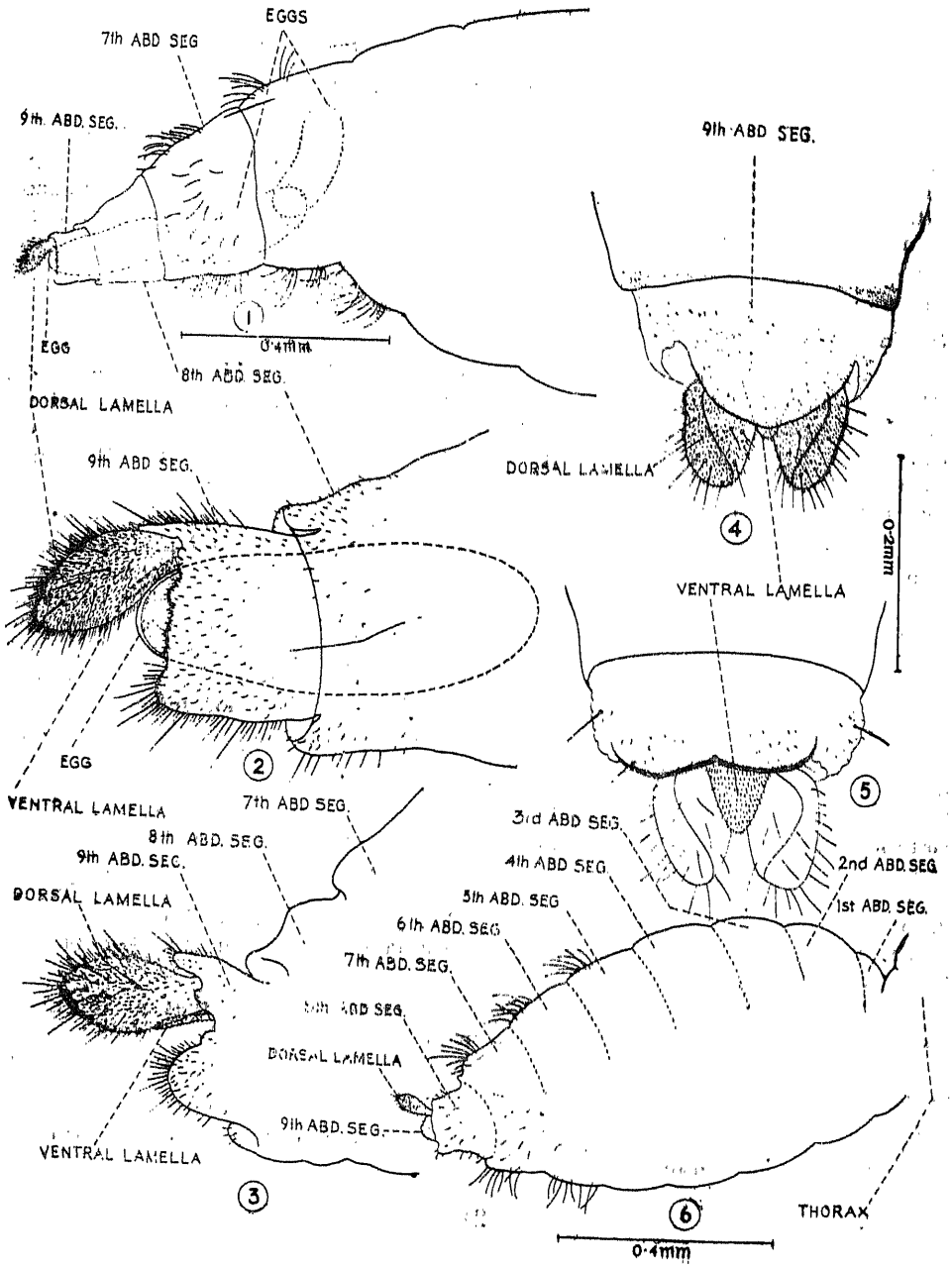
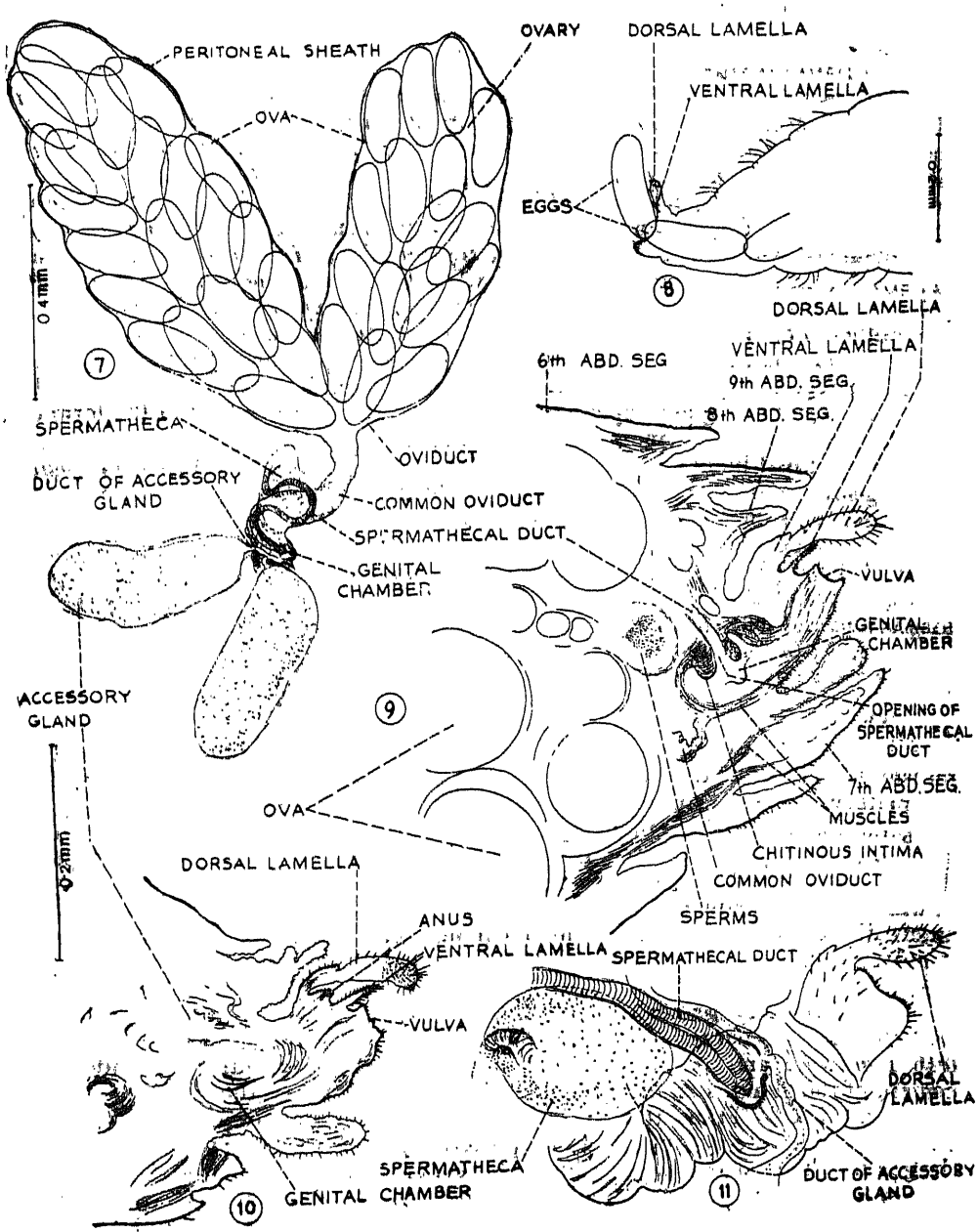
2. Quoted from Metcalfe, 1933.

EXPLANATION OF FIGURES

1, Posterior half of the abdomen ; 2, Tip of the abdomen, enlarged view (Extended) ; 3, Tip of the abdomen, enlarged view (Retracted) ; 4, Tip of the abdomen, enlarged view (dorsal) ; 5, Tip of the abdomen ; enlarged view (ventral) : 6, Abdomen full view ; 7, Internal female reproductive orgars ; 8, Posterior end of abdomen showing passing out of the eggs ; 9, Longitudinal sect on of the posterior end of the abdomen ; 10, Longitudinal section of the posterior end of the abdomen showing the anal opening between the dorsal and ventral lamella ; 11, Genital chamber enlarged showing the opening of the duct of accessory glands and spermathecal duct.




PERITONEAL SHEATH
OVARY
OVA
0·4mm
7
SPERMATHECA
DUCT OF ACCESSORY GLAND
OVIDUCT
COMMON OVIDUCT
SPERMATHECAL DUCT
GENITAL CHAMBER
ACCESSORY GLAND
0·2mm
9
OVA
DORSAL LAMELLA
ANUS
VENTRAL LAMELLA
VULVA
GENITAL CHAMBER
10
DORSAL LAMELLA
VENTRAL LAMELLA
EGGS
8
DORSAL LAMELLA
6th ABD. SEG
VENTRAL LAMELLA
9th ABD. SEG.
8th ABD. SEG.
VULVA
GENITAL CHAMBER
OPENING OF SPERMATHECAL DUCT
7th ABD. SEG.
MUSCLES
CHITINOUS INTIMA
COMMON OVIDUCT
SPERMS
SPERMATHECAL DUCT
DORSAL LAMELLA
SPERMATHECA
11
DUCT OF ACCESSORY GLAND

The female genital aperture or vulva is a large extensile opening situated at the end of the ninth segment under the dorsal lamellae and just below the ventral lamella, thus the female genital pore is ventral in position. The anal opening is situated between the dorsal and ventral lamellae and is dorsal to the vulva (figs. 9, 10).

Internal reproductive organs

The ovaries (fig. 1) are large paired structures and occupy the maximum abdominal space, almost filling it. They extend, on either side of the gut, from the sixth abdominal segment onwards upto the first. The ovarioles are polytrophic type but in fully mature females, large number of elongated orange coloured ova are compactly placed inside a thin peritoneal sheath. The number of ova as counted in a number of females vary from about 15–50 in each ovary. The oviducts, which are simple posterior continuations of the sheath of the ovaries are short, thin walled tubes, soon joining with the common oviduct. The common oviduct is tubular and thick walled. Its internal epithelium is inconspicuos, the epithelial cells have no clear cell boundaries and the nuclei are also not very distinct. The chitinous intimal lining is thin in the proximal part of the oviduct but in the region of genital chamber, where the spermathecal duct and the duct from the accessory gland open into it, it is strongly thickened in the form of a valve, which in whole mount appears like a shaddle-shaped structure. This thickened intimal lining of genital chamber has been called, in *Aschistonyx baranii* as the 'genital funnel' (Prasad and Grover, 1964) but its derivation from the valvifers and valvulae seems doubtful (Ansari, 1967). This structure, however, is not a part of the external genitalia, instead it is a simple modification of the intimal lining of the genital chamber (figs. 9, 11) and serves as a valve, when the eggs are passed out at the time of oviposition. Externally a thick coat of circular and longitudinal muscles invest the common oviduct. The genital chamber (fig. 9) has a supply of thick muscles, and opens to the outside through the female genital pore or the vulva at the tip of the ninth segment.

The spermatheca is single club-shaped, thin walled structure, located dorsally over the common oviduct near about its middle half (figs. 7, 11). It measures about 0·128 mm. long and 0·064 mm wide. From the anterior end of the spermatheca arises a spermathecal duct. Distally the duct before opening into the genital chamber through a single opening, splits into two which soon unite together. The spermatheca (in mated females) is found to contain mass of sperms. The spermathecal duct comprises of a simple single layered epithelium, the cells of which are not distinct and rest externally over a thin basement membrane. Internally there is a thick chitionous lining, which in whole mounts appears as annular rings.

The accessory glands are small sac-like thin walled structures associated with the female generative system. Each gland (fig. 7) is about 0·32 mm long and 0·16 mm wide and is located over the distal half of the ovary of its side. The content of the gland is an orange coloured fluid which gives the orange shade to the gland itself. From the distal end of the gland arises a thin tubular duct which runs over the common oviduct posteriorly and opens into the vagina or the genital chamber dorsally. The two ducts of the accessory glands join together to open by a single opening which lies posterior to the opening of the spermathecal duct (fig. 11) in the genital chamber. Histologically the accessory gland consits of a single layered epithelium, the cells of which are well nucleated and vacuolated

and rest externally on a thin besement membrane. There are no muscle coatings. The duct has a similar histology, except that the vacuoles are lacking.

Summary

1. The female reproductive system of *Coquillettomyia indica* sp. nov. has been studied in detail.

2. The ovipositor is lamellate type and is incapable of puncturing the plant tissues. The eggs, are therefore, released on the surface of the host plant.

3. The dorsal lamellae are large leaf-like, located dorso-laterally, the ventral lamella is simple and located in between the dorsal lamellae at the tip of the ninth abdominal segment.

4. The female external genital aperture or the vulva is ventral to the ventral lamella and is situated at the tip of the ninth abdominal segment. The anal opening is in between the two lamellae.

5. The internal female organs are a pair of ovaries, oviducts, common oviduct, genital chamber, paired accessory glands and a single spermatheca with spermathecal duct which gets splitted in its middle and again becomes fused into one.

6. The internal chitinous intima of the oviduct is thin but gets thickened into a shaddle-shaped valvular structure in the regions of the genital chamber which serves as a valve during passing of the eggs to the outside.

7. The spermathecal duct opens into the genital chamber by a common opening. The ducts of the accessory gland also open by a common opening and this opening is postesior to the opening of the spermathecal duct.

Acknowledgements

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Physiological Response of Sugarcane to Spraying of Gamma BHC over Setts after Planting[1]

By

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Introduction

Amongst the various isomers of Benzene hexachloride (BHC), Gamma isomer is most active biologically. Its mean lethal dose is 125 mg/kg as against 500 mg/kg, 1000 mg/kg and 6000 mg/kg of alpha, delta and beta isomers of BHC. Siddiqui *et al.* (1959) observed that Gamma BHC gave simultaneous control of sugarcane termites and shoot borers and resulted in increased tillering, plant growth and yield. Muthuswamy (1960) claimed that application of one lb. active ingredient per acre over the setts at planting gave good control of borers in the premonsoon period but it depressed germination of sugarcane. Singh and Sandhu (1961) claimed beneficial effect of Gamma BHC at 1·1 to 5·5 Kg/ha on sugar content of cane. They also observed (1963) significant increase in millable cane number and yield. Bhoj and Nath (1963) observed an increase of 5–6 M.T./acre in cane yield due to application of Gamma BHC (20%) over setts after planting. With a view to determining the physiological response of sugarcane to applications of Gamma BHC, an experiment was conducted for three years at Sugarcane Research Station, Shahjahanpur, Uttar Pradesh, the results of which are discussed in this paper.

Material and Method

The experiment was laid out with sugarcane *var* C. 0·453, in a randomised block design with four treatments *viz.* Control (0 Kg, 0·73 Kg, 3·64 Kg and 7·28 Kg doses of Gamma BHC (20%) per hectare. Four replications were maintand for all the treatments. Gamma BHC was dissolved in water. It was applied on setts after planting at the rate of about two thousand litre per hectare. The planting of sugarcane was done on February 12, February 16, and February, 13 during 1958–59, 1959–60 and 1960–61 respectively, in rows made 90 cm apart, at the rate of one three budded sett per 30 cm of the row length. Green manuring was done with *Dhaincha* and nitrogen was applied at the rate of 67 kg/ha during the first year and third year. During second year, when green manuring was not done, 112 kg N/ha was applied through inorganic fertilizer, as top dressing. The crop was irrigated three times during first year and second year and two times during third year in the pre-monsoon period. Weedings, hoeings and earthing were done uniformally in all the plots, when needed.

1. Contribution from the Section of Cane Physiology.
2. Cane Physiologist and Senior Physiological Assistant respectively.

Observations were recorded for germination, tillering, millable canes, height and weight of canes, yield and juice quality *viz.* sucrose % and purity coefficient. The ultimate recovery of sugar was also worked out. The data were analysed statistically and finally the pooled estimate for all the years was worked out.

Results and Discussion

Germination :

The germination of sugarcane setts was not influenced significantly by Gamma BHC in any year of trial or in their pooled estimate (Table 1). The claims of Muthuswamy (1960) that Gamma BHC depressed germination, therefore, could not be corroborated by these results.

TABLE I

Germination %

Sl. No.	Doses of Gamma BHC in Kg/ha	YEARS			Mean
		First	Second	Third	
1.	0 (control)	41·05	43·85	44·05	42·98
2.	0·73	43·13	45·13	44·70	44·32
3.	3·64	42·10	45·59	45·53	44·41
4.	7·28	40·65	45·29	43·74	43·23
	S.E.	1·12	0·55	0·59	0·53
	C.D. at 5%	N.S.	N.S.	N.S.	N.S.

Tillering :

The tillering capacity of plants was also not influenced by Gamma BHC significantly in two out of the three years of trial. In 1960-61, however, the two higher doses of Gamma BHC *viz.* 3·64 Kg/ha and 7·28 Kg/ha increased tillering significantly over control, as well as, over the lowest dose of 0·73 Kg/ha. In the pooled estimate, there was no significant variation between different treatments. The claims of Siddiqui *et al.* (1959) relating to increase in tillering due to Gamma BHC could not be substantiated (Table II).

TABLE II

Tiller/plant

Sl. No.	Doses of Gamma BHC in Kg/ha	YEARS			Mean
		First	Second	Third	
1.	0 (control)	4·05	4·70	3·70	4·15
2.	0·73	3·92	4·80	3·88	4·20
3.	3·64	3·87	5·00	4·47	4·45
4.	7·28	3·87	4·80	4·39	4·35
	S.E.	0·13	0·15	0·10	0·30
	C.D at 5%	N.S.	N.S.	0·33	N.S.

Millable canes :

Millable cane number was significantly increased with the two higher doses of 3·64 Kg and 7·28 Kg during 1958–59 and 1960-61 and in the pooled estimate of all the three years. There was, however, no significant variation between these two treatments themselves (Table III). The beneficial influence of Gamma BHC on cane number observed in the present studies confirmed the results of Singh and Sandhu (1963).

TABLE III

Millable canes/ha (thousands)

Sl. No.	Doses of Gamma BHC in Kg/ha	YEARS			Mean
		First	Second	Third	
1.	0 (control)	91·89	113·89	107·72	104·49
2.	0·73	95·03	112·72	109·66	105·80
3.	3·64	111·32	115·56	125·88	117·92
4.	7 28	117·35	116·65	126·55	120·18
	S.E.	3·20	3·12	1·98	1·80
	C.D. at 5%	10·24	N.S.	6·33	5·74

Cane Height :

The height of sugarcane was increased by the two higher doses of Gamma BHC in all the years of trial but the results of 1958–59 and the pooled estimate were only significant. There was no difference between these two doses themselves (Table IV). The findings of Siddiqui *et al.* (1959) that Gamma BHC increased growth was confirmed by these results.

TABLE IV

Cane Height in cm.

Sl. No.	Doses of Gamma BHC in Kg/ha	YEARS			Mean
		First	Second	Third	
1.	0 (control)	293·48	320·94	311·58	308·67
2.	0·73	301·54	311·22	314·68	309·15
3.	3·64	309·88	322·41	312·13	314·81
4.	7·28	317·57	328·31	315·04	320·31
	S.E.	4·24	5·24	5·62	2·48
	C.D. at 5%	13·35	N.S.	N.S.	7·93

Cane Yield :

The yield was influenced significantly by Gamma BHC in all the years of trial, as well as, in their pooled estimate. During 1958–59, all the three doses caused significant increase in yield over control. During 1959–60, however, the highest dose of 7·28 Kg/ha alone proved significant. In 1960–61, both highest and the medium doses of 7·28 Kg/ha and 3·64 Kg/ha caused significant improvement in yield. In the pooled result, all the three doses proved significant

over control but there was no significant variation between 3·64 Kg and 7·28 Kg doses, though these were superior to 0·73 Kg dose as well (Table V).

TABLE V

Cane Yield in Metric ton/ha.

Sl. No.	Doses of Gamma BHC in Kg/ha	YEARS			Mean
		First	Second	Third	
1.	0 (control)	67·68	81·75	75·24	74·88
2.	0·73	79·41	83·27	78·65	80·44
3.	3·64	96·54	85·59	90·53	90·88
4.	7·28	87·87	91·82	93·55	91·08
	S.E.	3·02	2·25	1·88	1·66
	C.D. at 5%	9·63	7·19	6·01	5·31

The significantly higher yields obtained with Gamma BHC in the pooled result of all the years lead to conclude that the insecticide exercised direct beneficial effect on the cane crop. The germination percentage was although similar in all the treatments, yet yield was increased due to its application. The chief contributing factors influenced by it were, the millable cane number and the height of individual cane. The increased yield obtained due to Gamma BHC in the present studies confirmed the earlier findings of Siddiqui *et al.* (1959), Singh and Sandhu (1963) and Bhoj and Nath (1963).

Sucrose :

The sucrose precentage in the sugarcane juice obtained from different treatments did not show significant variation in any year of trial or in their pooled estimate (Table VI). It, therefore, failed to confirm the findings of Singh and Sandhu (1961), who had claimed higher sugar content in canes due to Gamma BHC application.

TABLE VI

Sucrose % in juice

Sl. No.	Doses of Gamma BHC in Kg/ha	YEARS			Mean
		First	Second	Third	
1.	0 (control)	16·93	15·02	15·10	15·85
2.	0·73	16·86	15·45	15·42	15·91
3.	3·64	16·70	15·63	15·15	15·83
4.	7·28	16·83	15·00	15·60	15·81
	S.E.	0·44	0·51	0·30	0·22
	C.D. at 5%	N.S.	N.S.	N.S.	N.S.

Purity coefficient :

Like sucrose, the purity coefficient of juice also did not present significant variation between different treatments in any year of trial or in their pooled estimate (Table VII).

TABLE VII

Purity coefficient of juice

Sl. No.	Doses of Gamma BHC in Kg/ha	YEARS			Mean
		First	Second	Third	
1.	0 (control)	89·69	87·22	85·16	87·36
2.	0·73	90·57	87·90	85·16	87·88
3.	3·64	90·81	88·33	85·25	88·13
4.	7·28	90·53	84·59	85·66	86·93
	S.E.	0·71	2·17	0·48	0·65
	C.D. at 5%	N.S.	N.S.	N.S.	N.S.

The trend of improvement in tillering, millable cane formation, cane yield and recovery of sugar per hectare due to different doses of Gamma BHC over that of control has been shown in Fig. 1. It is seen that there was almost a steep increase in tillering, millable cane number, cane yield and the recovery of sugar per hectare upto 3·64 Kg/ha dose but it declined sharply afterwards. It showed that this dose may be regarded as optimum for pratical purposes.

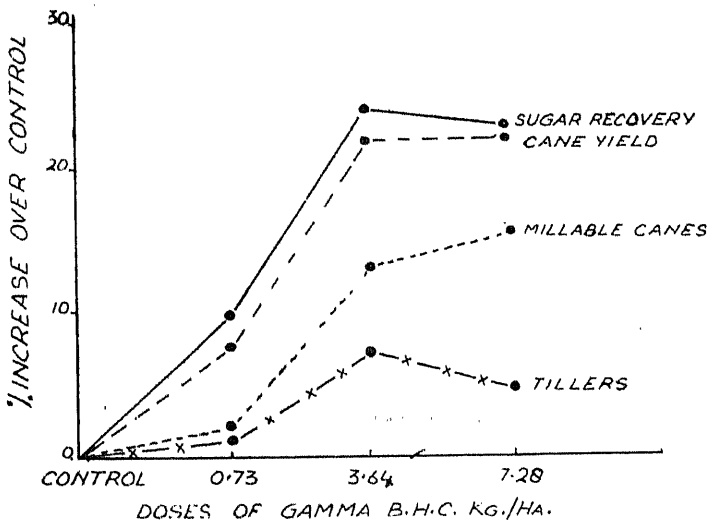

FIG. 1 EFFECT OF GAMMA BHC

Summary and Conclusions

To determine the physiological response of sugarcane to applications of Gamma BHC at planting time over the setts, an experiment was conducted for three years at Sugarcane Research Station, Shahjahanpur, Uttar Pradesh, in a randomised block design with four treatments *viz.* control, 0·73 Kg, 3·64 Kg, and 7·28 Kg doses of Gamma BHC and four replications. The insecticide at the

above rates was dissolved in water and was sprayed on the setts after planting at the rate of two thousand litre fluid per hectare. The results showed that :

(1) Germination was not influenced by Gamma BHC to any marked extent.

(2) Tillering showed no favourable effect of Gamma BHC in any year except during 1960–61, which needs further confirmation.

(3) Millable cane number was increased significantly by higher doses *viz.*, 3·64 Kg and 7·28 Kg of Gamma BHC in two out of the three years of trial as also in the pooled results. There was, however, no significant variation between these doses.

(4) Cane height was increased due to two higher doses of Gamma BHC mentioned above in all the years but the results of 1958–59 and pooled estimate were only significant.

(5) Cane yield was increased by the two higher doses of Gamma BHC in all the years of trial except during 1959–60, when 3·64 Kg dose was at par with control. There was, however, no difference between 3·64 Kg. and 7·28 Kg doses.

(6) Sucrose content and purity coefficient of juice was not influenced significantly by Gamma BHC treatments.

The results thus gave definite indication that Gamma BHC had a direct beneficial effect on the sugarcane crop in increasing its yield. It may, therefore, be applied invariably in the fields after cane planting, even if the chances for termite or borer attack are remote. Application of 3·64 Kg Gamma BHC/ha proved to be the best from economic point of view.

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Insect pests of Rice Plant in Haringhata (Nadia : West Bengal) : Field surveys and Bionomics

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Introduction

In an earlier note (Sen, 1964) the occurrence of 16 different species of insects from rice, mainly of the 'Aman' kind, was reported from Haringhata farms of the University of Kalyani and their neighbourhood. Half the number of the total species recorded was from the nursery plots of the seasonal rice. Since then more sustained work has revealed the prevalence of a much wider range of insect fauna, 39 species in all, in the different seasonal rice ('Boro', 'Aus', and 'Aman')* grown in the areas, not all of equal economic value, however.

Many of these pests particularly the important ones appeared in the isolated works of previous workers (Banerjee, 1956 ; Banerjee and Basu, 1956 ; Basu and Bera, 1958 ; Ghosh *et al*, 1960 ; Israel, 1956 ; Narayanan, 1953 ; Rao and Nagaraja, 1966 ; Sen, 1956 ; and Sengupta and Behura, 1959) but quite a few others remained undetected before. There are still some lacunae in the knowledge of the bionomics of even the principal pests which, therefore, need further intensive study.

Climatologically the rice growing seasons of the three kinds mentioned differed, more so, in respect of minimum temperature and rainfall, during the observational period covering the four years (1964 to 1967). The mean maximum and minimum temperature ranges for the different years during the 'Aman' growing seasons were of the order of 29°C to 30°C and 17°C to 19°C respectively, corresponding temperatures for the 'Aus' ranged from 30°C to 34°C and 25°C to 26°C and for the 'Boro' the ranges were 29°C to 36°C and 20°C to 21°C respectively. The atmospehric humidity during the period varied from 84 per cent in 'Aman', 80 per cent to 92 percent in 'Aus' and 79 per cent to 87 per cent in 'Boro' rice seasons. The rainfall remained within 1000 mm to 1500 mm during the main rice growing seasons ('Aman' and 'Aus') which fall in monsoon, while this dropped to 150 to 350 mm during the 'Boro' growing season.

Rice in this area is grown in rain-inundated fields, supplemented by irrigation from deep tubewells when necessary, particularly in Boro.

Material and Methods

All insects, mature and immature, found in association with the rice plants were collected from randomised plots, 3 of nursery and 6 of transplanted phase, during the morning hours 7·30 to 9·30 thrice a week. Nursery plots measured 8 m × 1·5 m each, and the transplanted plots 30 m × 10 m, and in each of these

*'Aman' – Winter rice from June/July to Nov./December.
'Aus' – Summer rice from April/May to August/September.
'Boro' – Spring rice from November/December to April/May.

selected plots six randomised blocks of one sq. m. were set apart for the routine collections.

Light traps and sweep nets were used for adult catches. Permanent slides of eggs and of larval stages, stained in Acid Fuchsin, the latter after softening in 10 per cent KOH, were made.

Insects for life-history study were also reared in potted rice plants placed in the open within a netted enclosure. The larval instars were determined from examination of moulted skins in the rearing cells or pots.

Field Surveys

(1) *Insects directly injurious to rice plant*: Various insect pests, 39 species as mentioned above. feeding on rice plants in Haringhata area (West Bengal) were recorded during 1964 and 1965, many of which were not known before (Table 1). Those which were recorded before by earlier workers in West Bengal have been marked with asterisk (*) in the list drawn up. The Lepidopteran leaf-rollers *Brachmia arotraea* Meyr. and *Susumia exigua* Btlr. causing damage to young rice leaves, the whole range of the dipteran stem-flies, and the two bugs *Eusarcocoris ventralis* Westw. and *Hermolaus* sp. sucking the milky juice out of newly formed grains and the five coleopteran (excepting *Hispa armigera* Oliv. and *Chaetocnema* sp.) will appear new to rice in Indian subregion. All the flies (4 species) recorded were pests of upland nursery plants particularly of 'Aman' (not seen in 'Boro') destroying the seedlings by feeding on the plant tissue from within the pseudostem. Two among them, *Atherigona indica* Mall. and *Oscinella* sp. destroying the nursery plants by feeding inside pseudostem are of special interest in view of the fact that certain allied genera, *Atherigona exigua* Stein. in Ceylon and *Oscinella frit* L. in East Pakistan have been of concern recently, the latter capable of causing gall in the plants like the *Pachydiplosis oryzae* (Wood-Mason) (Fernando, 1967 ; Alam, 1967). Among otner important findings are the three borers, *Sesamia inferens*, *Chilotraea auricilia* Ddgn., and *C. infuscatellus* Snell. as rice pests, until recently considered doubtful (Kapur, 1967), joining with the two most important rice stem-borers *Tryporyza incertulas* (Wlk.) and *Chilo partellus* (Swin.) in sharing the spoilage.

A few other species recorded previously (*Pseudaletia unipuncta* Haworth, *Cnaphalocrocis medinalis* Guen., *Proceras indicus* Kapur (possibly a misidentification and Kapur (*loc. cit.*) doubts it), among Lepidoptera, *Sogatella* sp. (Hemiptera), *Tanymecus indicus* Faust (Coleoptera), and the gall-midge *Pachydiplosis oryzae* (Wood-Mason) however remained undetected by us (Anonymous, 1954, 1965 ; Banerjee, *loc. cit.* ; Banerjee and Basu, *loc. cit.*).

(2) *Insects not directly injurious to rice plant* : Insects non-injurious or of doubtful value appearing in the rice plots are listed in Table 2. Altogether 26 species have been determined, out of which two species *Haltica cyanea* Weber and *Myllocerus* sp. have some pest value (Ghose *et al*, loc. cit).

Bionomics of the Important Pests

(1) *Tryporyza incertulas* (Wlk.).

Life-history : The female moth was found to commence laying eggs, which persisted for 2 or 3 days from second day after emergence, sometimes parthenogenetically and oviposited during night in captivity, very rarely during morning hours, in clusters more frequently on the dorsal surface of the rice leaves (boring to the ventral surface on emergence). Eggs laid per female were 48 to 211 in numbers covered by yellowish brown hairy scales. These hatched into tiny larvae in about 5 to 11 days depending on the climatic factors. The duration was

shorter, 5 to 7 days during August to October but 9 to 11 days during February, and 8 in November. The larvae creamy or yellowish white, possessed six instars. The first instar took 1 to 3 days, the second instar 2 or 3 days, the third 2 to 4 days, the fourth 2 to 7 days, the fifth 5 to 8 days and the last about 8 to 17 days. The entire larval period occupied 24 to 34 days depending on the season.

Pupation took place towards the base of the stems above the water mark and also in the stubbles in dried fields after harvesting of the crop, and the pupal period lasted 9 to 21 days depending on the climatological factors not yet analysed; pupae formed in February usually took the longest time.

Mature larvae also were availing the stubbles to tide over the unfavourable period in a state of diapause. Not more than one mature larva or pupa of the species was seen in the older stem or the stubble whether before or after harvest, although initially in the young tillers the attack started with a larger number of larvae of 1st or 2nd instar but as they grew older only 1 or 2 were found to penetrate a stem while the rest moved to other tillers, many of them perishing in the process of dispersal (Sato and Morimoto, 1962). Larvae undergoing diapause in the stubbles were relatively more abundant, the pupae forming only 9 to 16 per cent of the larval incidence depending on the kind of stubbles whether of 'Aman' or 'Aus'.

The adult moth emerged through a hole in the stem made by the larva before going to pupation. The sexes were represented in the ratio of 2 males to 1 female on an annual basis, reverse of that happening in the South (Banerjee and Pramanik, 1967), with seasonal fluctuations. Males were even more abundant in February showing a ratio of 3 males to 1 female. Contrary to the previous findings of three generations in West Bengal (Anonymous, 1965 ; Khan, 1967), the species we found possessed five generations a year, the first generation was spent in 'Boro' rice in cultivated fields during February/March to April, the second in both 'Aus' and 'Aman' crops during June and July, while the third and fourth generations were passed exclusively in 'Aman' rice plants during August/September and October/November respectively. The fifth generation started in November in 'Aman' completing its cycle among stubbles dragging on to February. In light trap catches throughout the year, the moth population showed two peaks, the first, a minor one in February/March during 'Boro' season, and a major peak in autumn during September/October when 'Aman' rice was in the field. The incidence of the moth dropped considerably during May and June rising again in July/August towards the end of 'Aus' season culminating finally in the major autumn peak of the species and then decreased again in December/January with the onset of cold weather.

Longevity in the adults varied from 3 to 9 days, the females died 24 to 48 hours after the cessation of egg laying. The entire life-cycle of the species varied from 6 weeks during July/August to 8 weeks in October/November.

Damage : The species caused widespread damage to rice plants both in the young stage during tillering[1] and in older plants at heading or flowering phase. The larvae produced "dead hearts" in young tillers by feeding on the plant tissue internally from larval borings so much so that the invaded tillers dried up and the shoots became dead and straw-coloured. In the older stems during flowering stage the mature larvae within the tunnel by eating out the vital tissue caused withering of the ear-heads to produce the characteristic "white heads" affecting

1. Seedlings in nursery phase in rice varieties of all 3 kinds ('Aman', 'Aus', 'Boro') remained unaffected. Only on rare occasions oviposition was noticed, but the development went no further.

grain-formation. The infestation rate of the borer was 5[1] to 13 per cent in 'Aman', 1·0 per cent or below in 'Aus' and 3 to 5 per cent in 'Boro'. The rate in 'Aman' rice during October/November was higher than that in 'Boro' rice in January/February in contrast to what happened in Malaya (Wyatt, 1957). The borer damage due to this species was most common during October/November which incidentally corresponds to 'Aman' season.

TABLE I

Insect pests of rice plants in Haringhata

Species	AUS		AMAN		BORO	
	Nursery	Tillers	Nursery	Tillers	Nursery	Tillers
Orthoptera						
Fam : Acrididae						
Acrida turrita L.	+	+	+	+	–	–
Aiolopus tamulus F.	–	–	–	+	–	–
Oxya sp.	+	+	+	+	–	–
O. fuscovittata (Marsch)	–	–	–	+	–	–
**Hieroglyphus banian* var. *elongata* Uv.	+	+	+	+	–	–
Fam : Tettigoniidae						
Lelana inflata Brun.	–	–	–	+	–	–
Isoptera						
Fam : Termitidae						
Microtermes obesi H.	–	+	–	+	–	–
Hemiptera						
Fam : Pentatomidae						
Eusarcocoris ventralis Westw.	–	+	–	+	–	–
Menida histrio Fab.	–	+	–	+	–	–
Hermolaus sp.	–	+	–	+	–	–
Fam : Coreidae						
**Leptocorisa acuta* Thun.	–	+	–	+	–	–
Fam : Aphididae						
**Tetraneura hirsuta* B.	+	+	–	–	–	–
**Rhopalosiphum rufiabdominalis* (Sasaki)	–	–	–	+	–	–
Fam : Coccidae						
**Ripersia oryzae* Green	–	+	+	+	–	–
Fam : Jessidae						
* *Nephotettix impicticeps* Ishihara	–	+	+	+	–	–
Thysanoptera						
Fam : Thripidae						
**Thrips oryzae* Will.	+	+	+	+	–	–

1. This rate refers to 1963 when the transplantation was delayed by a month owing to delayed monsoon.

Species	AUS		AMAN		BORO	
	Nursery	Tillers	Nursery	Tillers	Nursery	Tillers
Lepidoptera						
Fam : Hesperiidae						
**Pelopidas mathias* Fab.	–	–	+	+	–	–
Fam : Lymantriidae						
**Psalis pennatula* Fab.	–	+	+	+	–	–
Fam : Noctuidae						
**Sesamia inferens* Wlk.	–	+	–	+	–	+
**Spodoptera mauritia* Boisd.	–	–	+	+	–	–
Fam : Nymphalidae						
**Melanitis ismene* Cram.	–	–	+	+	–	–
Fam : Pyralidae						
**Tryporyza incertulas* (Wlk.)	–	+	+	+	–	+
**Chilo partellus* (Swin.)	+	+	–	+	–	+
Chilotraea infuscatellus Snell.	–	+	–	+	–	+
**C. auricilia* Ddgn.	–	+	–	+	–	+
Susumia exigua Btlr.	–	–	+	+	–	–
Fam : Pyraustidae					–	+
**Nymphula depunctalis* Guen.	–	–	–	+	–	+
Fam : Gelechiidae						
Brachmia arotraea Meyr.	–	–	+	+	–	–
Diptera						
Fam : Muscidae						
Atherigona indica Mall.	–	–	+	–	–	–
Fam : Chloropidae						
Steleocerus ensifer Thom.	–	–	+	–	–	–
Gaurax sp.	–	–	+	–	–	–
Oscinella sp.	–	–	+	–	–	–
Coleoptera						
Fam : Coccinellidae						
Harmonia arcuata (Fab.)	–	–	–	+	–	–
Verania discolor (Fab)	–	+	–	+	–	+
Fam : Chrysomelidae						
Monolepta nigrobilineata (Motsch.)	–	–	–	+	–	–
M. signata (Oliv.)	–	–	–	+	–	–
Chaetocnema sp.	+	+	+	+	+	+
**Hispa armigera* Oliv.	+	+	+	+	+	+
Rhadinosa leghua Maulik	–	–	+	+	+	+

+ Signifies positive finding ; – Signifies negative finding.

(2) *Chilo partellus* (Swin.)

Life history: The moths oviposited during night mostly, but on rare occasions during early morning also, on both dorsal and ventral surfaces of the rice leaf towards base in strips. The eggs remained covered by a shiny gelatinous coating. The female in rearing pots under enclosure laid 274 to 446 eggs in course of 3 or 4 days commencing from third day after emergence generally, during May and June and died within 24 to 48 hours after that. The incubation period of the egg was 4 to 9 days.

The duration of the six larval instars was : First instar 1 to 4 days, second instar 2 to 10 days, third instar 2 to 8 days, fourth instar 2 to 5 days, fifth instar 2 to 6 days, and the last instar 5 to 10 days. The entire larval period took 19 to 34 days. The mature larvae at the end of feeding period pupated inside the stems above the water surface or at the base of the stem at soil level or below in the dry fields and the pupation time in summer during May/June lasted for 5 to 7 or 8 days, rising to 10 or 12 days in cooler weather during October to February. Pupae of this species were more frequently obtained from 'Aus' stubbles after harvesting along with mature larvae in diapause.

The moth lived for 2 to 10 days, and the entire life-cycle of the species was completed in 5 to 8 weeks depending on climatological factors, the time occupied rising from summer to winter. The species seemed to possess 4 generations a year, diapausing as larvae during November to January in rice stubbles. The first generation was passed in 'Boro' plant during March to May, the second in 'Aus' standing rice during June to August, the third one in the 'Aman' plants during August to October and the fourth generation was passed in 'Aman' plants and partly in stubbles during November to February.

Damage: The nature of damage to rice plants both at tillering and maturing stages was similar to that caused by *T. incertulas*, but their infestation rates in the different kinds of rice differed. In 'Aman' rice the overall rate of damage varied from 1 to 4 or 5 per cent from season to session, in 'Aus' this was 1 to 7 per cent, and in 'Boro' the lowest rate of 1 per cent or below occurred.

(3) *Hispa armigera* Oliv.

Life history: The beetles oviposited inside the epidermal layers of the rice leaf inserting through the upper surface. Eggs were laid in small numbers, 1 to 9 per leaf; total laid per day per female was between 2 and 22 involving more than one leaf in the rearing pots inside enclosure. Egg-laying commenced 3 to 4 days after emergence of the female and continued for 10 days to a month or more depositing 43 to 102 eggs in captivity, and under field conditions during July and August, the number varied from 30 to 101. Oviposition was usually performed during night and rarely during morning hours. The incubation period of the egg varied from 3 to 5 days at room temperature in July.

The larvae passed through four instars; the first instar took 1 to 3 days, the second also 1 to 3 days, the third 1 to 4 days, and the fourth instar occupied 3 to 6 days when reared in glass jars among 'Aman' leaves during July and August. The entire larval period was completed in 9 to 16 days. Pupation occurred within the larval tunnel, and the stage occupied 4 to 7 days. The adult beetles came out through slits on the leaf surface and lived for 10 to 53 days and mated several times (up to 8) during life.

The entire life-cycle of the Hispa occupied 15 to 25 days. The species passed through 6 generations in a year, and was active among field crops during

June to February. One generation was detected during February in Boro rice, one during April/May among graminaceous weeds* acting as alternate hosts of the species, one during June in Aus and three others among Aman rice in the months of July/August, September/October and November in succession. The number of generations would seem to depend on the nature and extant of crops grown whether all the three kinds as in Haringhata were involved or single or double crops were principally concerned restricting the number of generations.

Damage : Both adults and larvae of the species fed on the green young leaves of the rice plants The beetle feeding on the chlorophyll of the tender leaves from outside produced characteristic white patches on the leaf surface, and the larvae feeding on the tissues inside the epidermal layers hollowed out the leaf and made irregular tunnels. When extensively damaged, the leaf assumed a burnt-up or parchment-like appearance, and this skeletal leaf membrane developed cracks at places. The pests in severe infestation devitalised the plants and normal formation of the earheads was affected to cause a lower yield. Infestation rate in the areas varied from 11 per cent to 49 per cent depending on the kind of rice and season ; the damage was highest in 'Aus' and least in 'Boro' rice. The beetles also fed on the leaves of nursery plants, but the damage was not so high as in the transplanted plots (Basu and Banerjee, 1957).

(4) *Leptocorisa acuta* Thun.

Life history : Oviposition by the female *Leptocorisa* started 2 or 3 days after mating which covered 1 hr. 30 min. to 4 hrs. in captivity, the female started courtship soon after emergence, as also observed by Akbar (1958). Eggs varying from 13 to 44 were laid at one sitting in 2 or 3 rows on either surface of the rice leaf. Eggs were oval creamy white when freshly laid, later turning brownish. The incubation period of the egg lasted for 5 or 6 days during July and August, when maximum breeding was noticed among 'Aus' crop.

The nymphs passed through five instars of which the first instar took 2 days to complete its cycle, the second instar 2 to 4 days, the third instar 2 or 3 days, the fourth instar 4 or 5 days, and the fifth instar 5 to 7 days, same as in *L. varicornis* (Akbar, *loc. cit.*). The total duration of the nymphal stage covered about 2 to 3 weeks. The longevity in the adult bug varied from 22 to 48 days during the period July to September in captivity. The entire life-cycle of the rice bug occupied about a month. One brood in a year of this species was recorded from rice at Haringhata as was also recorded by Banerjee (1956) elsewhere.

Damage : Both adults and nymphs attacked the rice plants, particularly of 'Aus' at the grain-forming stage. The bugs preferred to penetrate their piercing proboscis through the open lips at the point where the glumes met and were found sucking the milky juice out of the grains which were ultimately converted to empty chaffs. All stages of the nymph along with adults were found attacking a panicle at their peak emergence period during July to September in 'Aus' crop. Their number became reduced when the 'Aman' crop was in the grain stage as they are known to hibernate then ; equally the species was scarce in the 'Boro' crop as they avoid strong sun (Srivastava and Sexena, 1967). The bugs were also noticed to suck sap from leaves of tender seedlings. A brownish spot appeared around the puncture marks made by the proboscis of the bug but no gaping wound. These marks are quite distinct from the perforated holes made by the lepidopterous immature borer larvae which caused dark stains around open holes. The bug-induced chaffiness and grain loss varied from 3 to 80 per cent of the total

**Dactyloctenium aegyptium* (L.) Beauv., *Echinochloa colonum* (L.) Link., *Digitaria adscendens* Henr., *Eleusine indica* (L.) Gaertn., *Leptochloa filiformis* R. & S., and *Leersia hexandra* Sw.

grains formed in a panicle, but more often the chaffiness did not exceed 20 per cent (Anonymous, 1954 ; Alam, 1967).

TABLE 2

Species prevailing in rice fields but not injurious

Species	Aman rice	
	Nursery plots	Transplated plots
Orthoptera		
Fam : Gryllidae		
Trigonidium cicindeloides Ramb.	+	+
Fam : Tridactylidae		
Tridactylus japonicus Haan.	+	+
Fam : Tetrigidae		
Fieberiana sp.	+	+
Coleoptera		
Fam : Coccinellidae		
Epilachna sp.	+	+
Coccinella transversalis Fab.	+	+
Menochilus sexmaculata (Fab.)	+	+ Also from 'Aus' and 'Boro'.
Fam : Carabidae		
Acupalpus smaragdulus Fab.	-	+
Clivina sp.	-	+
Anoplogenius microgonus Bates.	-	+
Amblystomus sp.	+	+
Bembidion sp.	+	+
Casnoidea sp.	+	+
Fam : Hydrophilidae		
Coelostoma sp.	-	+
Fam : Staphylinidae		
Cryptobium sp.	-	+
Fam : Elateridae		
Drasterius collaris Cand.	-	+
D. sulcatulus Cand.	-	+
Lacon trifasciatus Cand. (?)	-	+
Aeolus sp.	-	+
Fam : Cleridae		
Orthrius sp.	-	+
Fam : Tenebrionidae		
Gonocephalum sp.	-	+
Fam : Chrysomelidae		
Podagrica bowringi Baly.	-	+
Haltica cyanea Weber.	-	+
Cassida obtusata Boh.	-	+
Fam : Curculionidae		
Apion sp.	+	+ Also from 'Boro'.
Myllocerus sp.	-	+
Praolepra sp.	-	+

+ signifies positive finding ; - signifies negative finding.

Summary

1. Rice pests, 39 species, comprising 7 Orders of insects : Lepidoptera (12 species), Hemiptera (8 species), Coleoptera (7 species), Orthoptera (6 species), Diptera (4 species), Thysanoptera (1 species) and Isoptera (1 species) have been recorded from Haringhata area in Nadia district (West Bengal).

2. Among the insect pests recorded, the two leaf-rollers, *Brachmia arotraea* Meyr. and *Susumia exigua* Btlr. damaging young leaves of rice plant, and all four dipterous stemflies, particularly *Atherigona indica* Mall. and *Oscinella* sp. destroying nursery plants by feeding inside pseudostems, as also two hemipterous species *Eusarcocoris ventralis* and *Hermolaus* sp. sucking out milky grains to empty chaff and the five Coleoptera in the list feeding on glumes in inflorescing rice plants appear to be newly recorded rice pests from India.

3. Life-history of four major rice pests, *Tryporyza incertulas* (Wlk.), *Chilo partellus* (Swin.) *Hispa armigera* Oliv. and *Leptocorisa acuta* Thun. has been given and although confirmatory in nature many new informations have emerged in relation to the habits and behaviour of the species. An account of damage caused by each is also given.

4. Diapause in the larvae of the stem-borers *Tryporyza incertulas* (Wlk.) and *Chilo partellus* (Swin.) and the number of generations each possessed have been determined from seasonal population studies. Generations in *Hispa armigera* Oliv. and in *Leptocorisa acuta* Thun. have also been worked out.

5. A list of non-injurious insects from rice plots including 23 species of Coleoptera and 3 of Orthoptera has been drawn up from field surveys.

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